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Transaction costs, crop-livestock integration participation, and income effects in China

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The crop-livestock integration model is the main path for the sustainable development of agriculture and animal husbandry in China, and farmers' participation behavior is critical to the formation of this model. So this paper based on a field survey data of 615 farmers in 10 pilot counties of Crop-Livestock Integration (CLI) in the dairy industry in the east, middle, and west of Inner Mongolia, the relationship among transaction costs, farmers' decision-making of participating in the CLI model, and income effects was analyzed using the Endogenous Switching Regression (ESR) model in this paper. The results show that under the current market environment, the proportion of farmers participating in the CLI model is 37.56% of the farmer surveyed. The high costs of information searching, negotiation, and execution are the critical factors to inhibit farmers from participating in the CLI model. The results of the counterfactual test of the ESR model show that the effect of the CLI model on the income of participated farmers is not noticeable, while the effect is more significant on the income of non-participating farmers. Moreover, there is no obvious heterogeneity in the effects of the farmer level and "farmers-to-farm" level CLI models on farmers' income. Based on these conclusions, this paper proposes that the government should actively promote the establishment of the information-sharing platform and training mechanism about the CLI model, reduce farmers' costs in information searching and negotiation, optimize the incentive policy of the CLI model, incorporate the farmers planting forage into the subsidy scope of the CLI model, improve the economic benefits of farmers participating in the CLI model, and stimulate the enthusiasm of farmers participating in the CLI model, so as to effectively promote the realization of the CLI model in the animal husbandry industry.

KEYWORDS

transaction costs, crop-livestock integration model, income effects, Endogenous Switching Regression model, farmer level CLI model, "farmers-to-farm" level CLI model

1 Introduction

Smallholder farmers participating in crop livestock integration (CLI) have a long history in China. For thousands of years, Chinese farmers have not only integrated crops and livestock, but also applied human manure back to the land to maintain soil fertility (King, 2011). However, historical CLI by smallholder farmers has not been maintained as China has transitioned to industrial agricultural production. Specialized livestock farms (e.g., hogs) have increasingly focused on animal production (Qinghai, 2021) with animal feed (e.g., soybeans) imported from Brazil and not grown locally due to farmland limitations in China (Yusheng et al., 2022). Fertility requirements of crops are met not by animal manure, but by chemical fertilizers, particularly Haber-Bosch industrially fixed nitrogen (Qinghai, 2021). Therefore, similar to other areas in the world, crops and livestock in China are typically not integrated (Matson et al., 1997; Shubin et al., 2020).

According to Jikun's forecast, Beef, mutton, and milk will be the food with the highest per capita consumption growth in China in the next 10 years (Jikun and Wei, 2022). Ration safety, feed or livestock products safety is the key issue of China's food safety (Jikun, 2021). The moderate scale development and the improvement of production efficiency of animal husbandry are also the realistic needs of developing the animal husbandry in China (Mingli et al., 2022). However, the fecal pollution caused by the large-scale development of animal husbandry (Qinghai, 2021) hinders the further development of the herbivorous animal husbandry.

Herbivores feed on forage (Mingli, 2015), The integration model of grass and animal husbandry follows the principle of the recycling between material and energy in ecology. It uses modern agricultural technology to organically combine grass and animal husbandry, promote ecological interactions over space and time between model components (e.g., crops, grasslands, and animals) (Asai et al., 2018), transforms the negative benefit of pollution into the positive benefit of resources (Xueting et al., 2020). Therefore, the Crop-Livestock Integration (CLI) model can generate higher economic efficiency by reducing input costs (Asai et al., 2018), increasing product yields (Mingli, 2015) and supply high-quality herbivorous livestock products (Tianlong et al., 2022).

In 2015, China proposed the "Grain to Feeding Crops" policy to rebuild the Crop-Livestock Integration (CLI) model by Replacing grain corn with feeding corn in the main corn producing areas. Then the China state also issued a series of incentive policies to promote the development of the CLI model. However, the rate of farm level CLI is still not high in China (Qinghai, 2021). The major constraints of farm level integration are related to the limited farm farmland available (Qinghai, 2021), combined with High transaction cost of farmland transfer (Biliang and Chen, 2008) and a loss in the skills and knowledge required to optimize both crop and livestock sub-systems (Moraine et al., 2014).

As an alternative to farm level CLI, the farmer level CLI model [farmer who with a certain scale of arable land planting grass and breeding animals (Qinghai, 2021)], and the "farmers-to-farm" level CLI (integration of grass farmers and animal farms with larger scales) are the main model of China's grass–animal husbandry combination. The farmer's participation is crucial to the occurrence of this integration model (Tianlong et al., 2022). Several authors (Houjian, 2012; Garrett et al., 2017; Ping and Lili, 2018; Xingjie et al., 2020, 2021; Xueting et al., 2020; Xingjie and Zhenhong, 2022) explore the critical factors of farmers' participating decision-making in the farmer level CLI model. Such as farmer' individual characteristics, family characteristics, the cognition of the CLI model, market economic benefits, technology subsidy, government training, and the organizational and institutional environment. But they pay more attention to farmers' adoption of the compound three-dimensional CLI model of "rice and shrimp co-culture" and less to farmers' participation in the CLI model of grass and animal husbandry on farmer level and "farmer-to-farm" level.

Different from the three-dimensional CLI model, the farmer level and "farmer-to-farm" level CLI model has spatial and temporal limitations (Asai et al., 2018). Especially, the farmers participating in the "farmer-to-farm" level CLI model can only realize the effective flow of material and energy in the grassland livestock industry through market transactions of planted forage and applied manure (Asai et al., 2018), objectively increasing the market risk faced by farmers (Tianlong et al., 2022). Therefore, the transaction costs faced by farmers in forage sales and manure purchase are the essential factors affecting their participation in the CLI model (Asai et al., 2018).

According to Coase (1937), the transaction costs are all the costs related to a market transaction (except production costs). But Arrow (1969) stipulates that transaction costs are all the costs incurred by the operation of incomplete market mechanisms. Apparently, Coase defines transaction costs from the micro level of business operations, whereas Arrow defines transaction costs from the macro level of market operations. Subsequently, many scholars also explored the connotation of transaction cost from the micro-enterprise operation level. According to Libecap (1986), transaction costs should be defined as bargaining cost, information cost, measurement cost, supervision cost, execution cost, and administrative action cost. Furebotn and Richter (2000) also defined transaction costs as the cost of searching information, the cost of transmitting information, the cost of bargaining, the cost of decision-making, the cost of execution, and the cost of administration. Asai et al. (2018) analyzed six cases (Asia, Europe, and America) of beyond farm level CLI, and find that the information cost, the negotiation cost of collective decision, and the execution and supervision cost are the critical factors in the formation of the beyond farm level CLI model. Other Scholars also observed that the high information searching cost existed in the CLI model (Oelofse et al., 2013; Asai et al., 2014). However, there are rare empirical studies on the transaction cost and farmers' participation in the CLI model farmer level and "farmer-to-farm" level.

According to Schultz's "rational smallholder" theory, the economic benefit is the starting point of farmers' behavior of decision-making (Xueting et al., 2020), an important indicator of the CLI model realizing its social benefits (Qinghai, 2021), and also the crux of the sustainable development of the CLI model. several authors have discussed the income effect of CLI model, and some studies find that the CLI model can increase the soil organic content (Brown and Huggins, 2012; Fawen et al., 2021), raise the efficiency of fertilizer use (Tianlong et al., 2022), reduce input cost (Jian et al., 2019; Han et al., 2023). By replacing fertilizer with manure (Xiaoli and Yingheng, 2012; Chang and Juan, 2016), and enhance farmer's income from planting industry (Anderson and Schatz, 2003; Huan et al., 2018; Haixiu et al., 2019). Especially, the farmer level CLI model use farmers' forage directly in their breeding industry, which can not only reduce the breeding cost (Dan et al., 2022), but also improve the output and quality of livestock products (Qinghai, 2021; Tianlong et al., 2022), thus improving farmers' income from breeding industry. But some studies find that because it is difficult for farmers to guarantee the quality of forage, the income from forage planted by farmers is also not guaranteed (Shijuan et al., 2020). Xiaofei and Shuhao (2020) also found that due to the existence of technical losses, the cost saving effect of the CLI model is not significant.

The current research on the income effect of the CLI model mainly adopted descriptive statistical analysis or a linear regression method (Yiran et al., 2019; Tianlong et al., 2022).

And regarded the farmers' participation behavior as a strict exogenous variable. However, the farmers participation behavior of the CLI model is not a random event but a self-selection process influenced by observable factors and unobservable factors (Xueting et al., 2020). By simply utilizing descriptive analysis or the OLS model, the self-selection and endogenous problems of farmers participating in the CLI model can be ignored; therefore, it is impossible to obtain a consistent estimator without bias (Xiao et al., 2023). The ESR model can correct the self-selection bias caused by observable and unobservable factors to ensure the robustness of empirical results (Xiao et al., 2023).

In this context the goal of our study, which was based on field survey data of 615 farmers in Inner Mongolia, was to adopt the ESR model to correct for self-selection bias. Therefore, one of our objectives was to empirically examine the impact of transaction costs on farmers' participation decision-making during crop-livestock integration (CLI) at both the farmer level and "farmers-to-farm" level. Transaction costs include costs such as information cost, negotiation cost and execution cost. A second objective was to explore the net income effect of CLI at both the farmer level and the "farmers-to-farm" level in China.

2 Materials and methods

2.1 Data source

The data studied in this paper came from the field investigation of the dairy cattle industry in 10 "Grain to Feeding Crops" pilot banners (counties) in the eastern, central, and western regions of Inner Mongolia in July 2021, January 2022, and July 2022. The sampling of this survey data combined stratified sampling and random sampling. The specific sampling instructions are as follows: step one, fully considered the development of dairy industry in Inner Mongolia and the different development characteristics of the eastern, central, and western regions, as well as the availability of samples and other factors to select 10 pilot banners and counties of dairy cattle breeding CLI in five league cities, including Chifeng City (Ongniud Banner and Aruhorqin Banner) and Xing'an League (Keyouqian Banner) in the eastern region, Hohhot in the central region (Helinger County, Tokto County, and Tumete Left Banner), Baotou City in the western region (Tumete Right Banner and Jiuyuan District), and Bayannur City (Hangjinhou Banner and Dengkou County); step two, randomly selected two towns in each banner and county; step three, randomly selected three villages in each town (in Hangjinhou Banner and Dengkou County of Bayannur City and Ongniud Banner and Aruhorqin Banner of Chifeng, randomly selected four villages from each township (town) to particularly study farmers' forage planting); step four, randomly selected 10 farmers in each village, of which five were participating in the CLI model and five were not. During the field survey, the sample size was fine-tuned according to the specific situation of villages, and 618 samples of farmers were obtained. After removing samples with missing data and other unreasonable information, there were 615 final effective samples, and the sample efficiency was 99.51%. The survey adopted the "one-to-one" interview method. Researchers interviewed farmers face to face and then filled in a survey questionnaire.

2.2 Variable selection

The variables used in the Endogenous Switching Regression (ESR) model include interpreted (explained), core explanatory, and control variables. The ESR model has two interpreted (explained) variables. The interpreted (explained) variable in the first stage is the decision-making variable of farmers' participation in the CLI model, for which 1 means farmers participate, and 0 means farmers do not participate. The interpreted (explained) variable in the second stage is the household income variable. According to Dan et al. (2022), this paper measures household income by the per capita disposable income of the household.

The core explanatory variables are the transaction costs. This study, which is consistent with the study conducted by Asai et al. (2018), measures transaction costs from the perspectives of information cost, negotiation cost, and execution cost, and measures the information cost, negotiation cost, and execution cost by the difficulty level of obtaining information, the scarcity degree of human capital, and the distance from the nearest farm when farmers sell forage, respectively. The negotiation cost is a reverse indicator; the higher the value, the lower the negotiation cost.

According to Zhigang and Liang (2018), control variables include respondents' individual characteristics, household characteristics, and village-level characteristics. Individual characteristic variables include the respondent's age, education level, political landscape, participation in forage planting training, and cognition of the CLI policy. Family characteristic variables include labor endowment, per capita cultivated land area, degree of fragmentation of cultivated land, the proportion of income from agriculture and animal husbandry, and the situation of breeding. The village-level characteristics include the per capita income of the village, the situation of the village cooperatives, and the situation of the village farms.

Table 1 shows the definition of variables and the results of descriptive statistical analysis. It can be seen from Table 1 that the income of farmers participating in the CLI model is 44,550 yuan (USD 6,206),[1] significantly higher than the 23,110 yuan (USD 3,219) of the income of farmers not participating. The average costs of information and negotiation faced by farmers participating and not participating are different at the 1% significance level, while the average execution cost is different at the 5% significance level. From the average results, the costs of information searching and negotiation cost faced by participated farmers are significantly lower than that of non-participating farmers, while the execution cost of participated farmers is higher than that of non-participating farmers. From the results of control variables, in addition to variables of the labor, the land

1 All currency amounts in this paper are translated into US dollars using the exchange rate published by the People's Bank of China on October 26, 2023 (US $1 = 7.1784 RMB). http://www.pbc.gov.cn/zhengcehuobisi/125207/125217/125925/5112384/index.html.

TABLE 1 Variables definition and descriptive statistics.

	Variables definition and assignment	Participated ($n = 231$)	Non-participated ($n = 384$)	T-value
Farmers' income	Per capita disposable income of farmers (10,000 yuan/person)	4.455	2.311	2.144***
Participate in CLI	Plant forage? (1 = yes, 0 = no)	1	0	
Information cost	Ease of obtaining information on planting technology and forage sales (1 = very easy, 2 = relatively easy, 3 = average, 4 = relatively difficult, 5 = very difficult)	2	3.474	−1.474***
Negotiation cost	How many livestock farm's manager do you know? (number of manager)	3.156	0.802	2.354***
Execution cost	How many kilometers is the nearest pasture from your home? (km)	14.842	10.127	4.715**
Labor	Number of the family labor (person)	2.784	2.832	−0.039
Per capita land	Per capita farmland (mu/person)	46.213	24.407	21.805***
Land fragmentation	Area of a piece of farmland (mu/piece)	30.777	27.126	3.652
Specialization level	Income from agriculture and animal husbandry/total household income	1.357	0.617	0.740
Farmers' breeding	Are you engaged in breeding? (1= yes, 0 = no)	0.697	0.568	0.129***
Age	Actual age of respondents (year)	51.489	54.474	−2.985***
Education level	Actual education years of farmers (year)	8.221	7.703	0.518**
Politics status	Are you a party member? (1 = party member, 0 = other)	0.333	0.211	0.122***
Farmers' training	Do you take part in forage planting training? (1 = yes, 0 = no)	0.355	0.138	0.217***
Farmers' cognition	Understanding of CLI policies (1 = basically unknown, 2 = little, 3 = average, 4 = relatively understood, 5 = very understood)	2.913	2.299	0.614***
Village income	Per capita annual income of the village (10,000 yuan)	1.449	1.135	0.314***
Village farms	Is there a farm in this village? (1 = yes, 0 = no)	0.675	0.703	−0.028
Village cooperatives	Is there a cooperative for planting forage in this village? (1 = yes, 0 = no)	0.541	0.430	0.111***

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.

fragmentation, Farmers' specialization level, and the village farm, the mean values of other control variables are significantly different between farmers participating in and not participating in the CLI model. Therefore, the initial T-test results of the mean values of variables show that farmers participate in CLI model behavior is a self-selection behavior made under the influence of internal and external factors, so it is necessary to adopt the ESR model.

2.3 Model setting

The farmers participation behavior of the CLI model is not a random event but a self-selection process influenced by observable factors such as farmers' personal characteristics, family characteristics, and the trading environment characteristics and unobservable factors such as farmers' cognition, production, and trading ability (Xueting et al., 2020). Owing to participated and non- participated farmer's initial conditions are different; the division of participating farmers and non-participating farmers in the sample is not random. Moreover, because the participation behaviors of participating farmers and non-participating farmers are often not directly observable, the process of estimating the income effect of the CLI model is characterized by sample selection bias. By simply utilizing descriptive analysis or the OLS model, the self-selection and endogenous problems of farmers participating in the CLI model can be ignored; therefore, it is impossible to obtain a consistent estimator without bias (Xiao et al., 2023).

The 2SLS, PMS, Heckman, and ESR model can all solve endogeneity problems; furthermore, the 2SLS model can solve the endogeneity problem of missing variables, sample autocorrelation, and mutual causation. The PMS, Heckman, and ESR models can solve the endogeneity problem occasioned by sample self-selection; however, PMS mainly corrects the problem of sample self-selection occasioned by observable variables, and the Heckman and ESR model can correct the self-selection problems occasioned by observable and unobservable variables. This notwithstanding, the Heckman model cannot obtain the non-participated farmer's income effect. The ESR model not only corrects the self-selection problems occasioned by observable and unobservable variables, but also obtains the actual and counterfactual income

of participating and non-participating farmers based on the counterfactual framework.

Therefore, this paper uses the ESR model to estimate the relationship among transaction costs, farmers' decision-making of participating in the CLI model, and income effects. The ESR model includes two stages: the first one is the behavior decision model, and the second one is the income effects model. In the behavior decision model of the first stage, the behavior of farmers participating in the CLI model is affected by the latent variable, which cannot be directly observed but can be represented by a series of observable exogenous variables. According to the theoretical analysis, as rational economic people, farmers take part in the model of CLI to maximize family utility. Assume that the potential total utility of farmers participating in the model of CLI is A_{im}^{*}, the potential total utility of farmers not participating in the CLI model is A_{in}^{*}, then the condition for farmers to choose to participate in the model of CLI is $A_{im}^{*} - A_{in}^{*} > 0$, that is, the potential total utility of farmers participating in the CLI model is greater than that of farmers not participating. The selection model of farmers' participation in the CLI can be expressed as follows:

$$\mathrm{A_i^*} = \pi \mathrm{X_i} + \beta \mathrm{V_i} + \varphi_{\mathrm{i}}\ \mathrm{A_i} = \left\{1, \text{if} \quad \mathrm{A_i^*} > 0 \quad 0, \text{if} \quad \mathrm{A_i^*} \le 0\right\} \quad (1)$$

In the formula (1), A_i^{*} represents the unobservable latent variable affecting farmers' participation in the CLI mode; A_i represents whether farmers participate in the CLI mode, where $A_i = 1$ indicates that farmers participate in the CLI mode, and $A_i = 0$ indicates that farmers do not participate; X_i and V_i are the exogenous factors affecting farmers' decision-making of participating in the CLI model, among which X_i is the transaction cost faced by farmers, the key independent variable in this paper; V_i is one of the variables of the individual farmer characteristics, family characteristics, and village-level characteristics; π and β are the parameters to be estimated, and φ_i is a random disturbance term.

At the second stage of the ESR model, the income effects when $A_i = 1$ and $A_i = 0$ are estimated, respectively, and the formulas are as follows:

$$Y_{i1} = \psi_{i1} Z_{i1}^{'} + \upsilon_{i1}, \text{when } A_i = 1 \quad (2)$$

$$Y_{i0} = \psi_{i0} Z_{i0}^{'} + \upsilon_{i0}, \text{when } A_i = 0 \quad (3)$$

where, Y_{i1} and Y_{i0} in formulas (2) and (3) are the incomes of farmers who participate in and do not participate in the CLI, respectively; Z_{i1} and Z_{i0} are the individual characteristics, family characteristics, and village-level characteristics that affect the income of farmers, and υ_{i1} and υ_{i0} are random disturbance terms. If the unobservable factors affect the behavior selection model (1) and the income models (2) and (3) at the same time, the random disturbance term of formula (1) φ_{ii} is significantly related to the random disturbance terms of formulas (2) and (3) υ_i, leading to biased estimation results of income models (2) and (3). To solve this problem, the ESR model adds the inverse Mills coefficient (λ) obtained from the estimation in the first stage to formulas (2) and (3) and corrects the estimation bias caused by unobservable variables, ensuring the unbiasedness of estimation of the income effects model. The specific formulas are as follows:

$$\mathrm{Y_{i1}} = \psi_{\mathrm{i1}} \mathrm{Z_{i1}^{'}} + \gamma_{\mu 1} \lambda_{\mathrm{i1}} + \upsilon_{\mathrm{i1}}, \text{when } \mathrm{A_i} = 1 \quad (4)$$

$$\mathrm{Y_{i0}} = \psi_{\mathrm{i0}} \mathrm{Z_{i0}^{'}} + \gamma_{\mu 0} \lambda_{\mathrm{i0}} + \upsilon_{\mathrm{i0}}, \text{when } \mathrm{A_i} = 0 \quad (5)$$

where $\rho_{\mu 1}$ ($\rho_{\mu 1} = \frac{\sigma_{\mu 1}}{\sigma_{\mu}\sigma_{i1}}$) and $\rho_{\mu 0}$ ($\rho_{\mu 0} = \frac{\sigma_{\mu 0}}{\sigma_{\mu}\sigma_{i0}}$) calculated by the regression model are the correlation coefficients of the covariance of the farmers' participation behavior model (1) and the income effects models (2) and (3). If $\rho_{\mu 1}$ and $\rho_{\mu 0}$ are significant, it indicates that the sample has a self-selection problem, and the ESR model is effective.

Meanwhile, based on the counterfactual analysis method, the ESR model estimates the income difference between farmers participating in and not participating in the CLI model under the actual and counterfactual conditions, so as to analyze the income effects of farmers' participation in the CLI model. The following formulas (6) and (7) are the expected value of the total household income of farmers participating in (treatment group) and not participate in the CLI (control group) in the actual situation.

$$\mathrm{E}\left[(\mathrm{Y_{i1}}|\mathrm{A_i} = 1)\right] = \psi_{\mathrm{i1}} \mathrm{Z_{i1}^{'}} + \gamma_{\mu 1} \lambda_{\mathrm{i1}} \quad (6)$$

$$\mathrm{E}\left[(\mathrm{Y_{i0}}|\mathrm{A_i} = 0)\right] = \psi_{\mathrm{i0}} \mathrm{Z_{i0}^{'}} + \gamma_{\mu 0} \lambda_{\mathrm{i0}} \quad (7)$$

Under the framework of counterfactual analysis, For the farmers (treatment group) participating in the model of CLI, the expected value of the total household income when they do not participate in the model of CLI, and for the farmers (control group) who do not participate in the model of CLI, the expected value of total household income when they participate in the model of CLI are as follow formulas (8) and (9):

$$\mathrm{E}\left[(\mathrm{Y_{i0}}|\mathrm{A_i} = 1)\right] = \psi_{\mathrm{i0}} \mathrm{Z_{i1}^{'}} + \gamma_{\mu 0} \lambda_{\mathrm{i1}} \quad (8)$$

$$\mathrm{E}\left[(\mathrm{Y_{i1}}|\mathrm{A_i} = 0)\right] = \psi_{\mathrm{i1}} \mathrm{Z_{i0}^{'}} + \gamma_{\mu 1} \lambda_{\mathrm{i0}} \quad (9)$$

The average treatment utility ATT of farmers participating in the CLI model and the average treatment utility ATU of farmers not participating in the CLI model are as follow formulas (10) and (11):

$$\begin{aligned} \mathrm{ATT} &= \mathrm{E}\left[(\mathrm{Y_{i1}}|\mathrm{A_i} = 1)\right] - \mathrm{E}\left[(\mathrm{Y_{i0}}|\mathrm{A_i} = 1)\right] \\ &= (\psi_{\mathrm{i1}} - \psi_{\mathrm{i0}}) \mathrm{Z_{i1}^{'}} + (\gamma_{\mu 1} - \gamma_{\mu 0}) \lambda_{\mathrm{i1}} \end{aligned} \quad (10)$$

$$\begin{aligned} \mathrm{ATU} &= \mathrm{E}\left[(\mathrm{Y_{i1}}|\mathrm{A_i} = 0)\right] - \mathrm{E}\left[(\mathrm{Y_{i0}}|\mathrm{A_i} = 0)\right] \\ &= (\psi_{\mathrm{i1}} - \psi_{\mathrm{i0}}) \mathrm{Z_{i0}^{'}} + (\gamma_{\mu 1} - \gamma_{\mu 0}) \lambda_{\mathrm{i0}} \end{aligned} \quad (11)$$

3 Empirical results analysis

3.1 Benchmark regression analysis

3.1.1 Empirical analysis of transaction costs and farmers' participation in the CLI model

This paper uses the ESR model to empirically test the transaction costs, farmers' decision-making of participating in the CLI model, and the income effects. As shown in Table 2, $\rho_{\mu 0}^{0}$ presents a positive correlation at the 5% significance level, indicating that samples have self-selection problems caused by unobservable factors. It is reasonable to adopt the ESR model. The LR model and the Log Likelihood model are significant at 10 and

TABLE 2 Test of transaction costs, farmers' participation in the CLI model, and income effects.

Variables	Farmers' participate in CLI		Farmer's income effect			
			Participated		Non-participated	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Information cost	−0.359***	0.051				
Negotiation cost	0.366***	0.049				
Execution cost	−0.007*	0.004				
Labor	0.140*	0.080	−0.879***	0.322	−0.058	0.132
Per capita land	0.014***	0.003	0.055***	0.007	0.051***	0.005
Land fragmentation	−0.005***	0.001	−0.005	0.007	−0.005***	0.002
Specialization level	0.013	0.024	−0.018	0.027	−0.008	0.035
Farmers' breeding	0.455**	0.177	0.361	0.729	0.034	0.271
Age	−0.009	0.009	0.076**	0.037	−0.020	0.014
Education level	−0.059**	0.028	0.192*	0.101	0.102**	0.046
Politics status	0.297	0.181	−0.009	0.675	0.034	0.324
Farmers' training	0.290	0.181	−0.153	0.642	−0.054	0.377
Farmers' cognition	0.134*	0.069	−0.052	0.282	−0.008	0.117
Village income	0.088	0.095	−0.401	0.325	0.591***	0.235
Village farms	−0.109	0.202	−2.842***	0.857	−0.693**	0.290
Village cooperatives	0.121	0.164	1.315*	0.681	−0.265	0.281
Constant term	−0.620	0.637	2.264	2.563	1.375	1.114
Region	Control		Control		Control	
N	615		231		384	
$\ln \sigma_{\rho^0}^0$					0.846***	0.037
$\rho_{\mu^0}^0$					0.256**	0.123
$\ln \sigma_{\rho^1}^1$			1.424***	0.047		
$\rho_{\mu^1}^1$			−0.185	0.168		
LR	4.95*					
Loglikelihood	−1,723.3477***					

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.
The results in the table are regression parameters and (standard error).

1% significance levels, indicating that the overall estimation effect of the ESR model is effective.

According to the regression results of decision-making in the first stage of the ESR model, the costs of information and execution are negatively correlated with farmers' participation in the CLI model at the significance levels of 1% and 10%, respectively, while the negotiation cost is positively correlated at the significance level of 1% (the negotiation cost is a negative indicator, the higher the value, the lower the negotiation cost), indicating that the higher the costs of information, negotiation, and execution faced by farmers, the less their participation in the CLI model. Therefore, the transaction costs are the critical factors inhibiting farmers' participation in the CLI model.

From the perspective of control variables, the labor endowment, per land, farmers' breeding, and farmers' cognition of the CLI are positively related to farmers' participating in the CLI model and encourage farmers to take part in the CLI model. However, the degree of land fragmentation and the education level are negatively correlated with the participation of farmers in the CLI model at significant levels of 1 and 5%, respectively, inhibiting farmers from participating in the CLI model. The negative correlation between the education level and the participation behavior of farmers in the CLI model may be due to the fact that most of the farmers participating in the CLI model are older, generally less educated in rural areas but have accumulated more experience, so they are more willing to choose the CLI model.

3.1.2 Empirical analysis of the income effects of the CLI model

Table 3 shows the test results of the average treatment effect of the income of farmers participating in and not participating in the CLI model. Column A in Table 3 is farmers' income in the actual situation, column B is farmers' income in the counterfactual

situation, and columns C and D are the average treatment effects ATT and ATU of the income of farmers participating in and not participating in the CLI model, respectively, and the specific calculation methods are ATT = A − B, ATU = B − A. Table 3 shows that the per capita disposable annual income of farmers participating in the CLI model is 44,550 yuan (USD 6,206) in the actual situation and 40,780 yuan (USD 5,681)in the counterfactual situation. Participating in the CLI model only increases the per capita disposable income of farmers by 3,770 yuan (USD 525) and fails the statistical 10% significance test, indicating that the CLI model has no positive effect on the income of participated farmers. Hypothesis H2b in this paper is verified, which may be the basic reason for the low proportion of farmers participating in the CLI model at this stage. However, the counterfactual analysis of the income effects of non-participating farmers shows that if non-participating farmers participate in the CLI model, their per capita disposable income will increase from 23,110 yuan (USD 3,219) to 46,680 yuan (USD 6,502), which can increase by 23,570 yuan (USD 3,283) and pass the 1% significance test. It indicates that compared with participated farmers, the CLI model has a more obvious effect on promoting the income of non-participating farmers. However, due to the high transaction costs, when farmers conduct decision-making, they consider risk aversion more, thus ultimately deciding not to participate in the CLI model.

From the results of the control variables (Table 2), the variables of per-land, ages, education level, and whether the farmers' village has a cooperative for planting forage have a significant positive correlation with per capita disposable income of participated farmers, while the variables of family labor and whether the farmers' village has a farm have a significant negative correlation with per capita disposable income of participated farmers. Other control variables fail the significance test. The variables of per-land, education level, and per capita disposable income of the village are significantly positively correlated with per capita disposable income of non-participating farmers, while the variables of land fragmentation level and whether the village has a farm are significantly negatively correlated with per capita disposable income of non-participating farmers. Other control variables fail the significance test.

3.2 Robustness analysis

This paper replaces the regression model and dependent variables to conduct the robustness test, checking the robustness of the above results. Considering that there may be other endogenous problems besides the self-selection problem in the participation behavior of farmers in the CLI, the extended regression model (ERM), which can simultaneously consider the self-selection of samples and other endogenous problems, is used to re-estimate. The results are shown in columns 5–7 of Table 4 and columns 6–8 of Table 5. At the same time, the per capita agricultural and animal husbandry income is taken as the alternative variable of farmers' income, and the ESR model is used to re-estimate. The results are shown in columns 2–4 of Table 4 and columns 2–5 of Table 5. The robustness test results show that the estimated results of ATT and ATU are basically consistent with the benchmark regression results, indicating that the empirical results of the benchmark regression are robust.

3.3 Heterogeneity analysis

The CLI model can be divided into the farmer level CLI model (internal circular model) and the "farmers-to-farm" level CLI model (external circular) (Shubin et al., 2020). Compared with the farmer level CLI model, the "farmers-to-farm" level CLI model needs to exchange forage and manure between different entities. Not only is the process of farmers selling forage constrained by transaction costs, such as information searching, negotiation, and execution, but also the process of applying manure to fields is constrained by a series of cost factors, such as purchase, transportation (Tianlong et al., 2022), and labor force. Therefore, there may be heterogeneity in the promotion of farmers' income by farmer level and "farmers-to-farm" level CLI models. Based on it, this paper divides the CLI model into farmer level and "farmers-to-farm" level CLI models, takes the farmers participating in the farmer level and "farmers-to-farm" level CLI models as the treatment group, the farmers who do not participate in the CLI model as the control group, and tests the transaction costs, decision-making of participating in the farmer level and "farmers-to-farm" level CLI models, and income effects (see Table 6). By analyzing the estimated results of transaction costs and farmers' decision-making of participating in the first stage, the information cost is negatively correlated with farmers' behavior of participating in the farmer level and "farmers-to-farm" level CLI models at the level of 1% significance, the negotiation cost is positively correlated with farmers' behavior of participating in the farmer level and "farmers-to-farm" level CLI models at the level of 1% significance, and the execution cost is negatively correlated with farmers' behavior of participating in the farmer level CLI model at the level of 10% significance, it is also negatively correlated with farmers' behavior of participating in the "farmers-to-farm" level CLI model, but it fails the significance test. It indicates that the higher the costs of information searching and negotiation faced by farmers, the more reluctant farmers are to participate in the CLI model, which is consistent with the total sample results. From the perspective of the regression coefficient, the information cost and negotiation cost have a more significant inhibitory effect on farmers' participation in the "farmers-to-farm" level CLI model, indicating that the information cost and negotiation cost have a more obvious inhibitory effect on farmers' participation in the "farmers-to-farm" level CLI model.

Table 7 shows the test results of the average treatment effects of the farmer level and "farmers-to-farm" level CLI models on farmers' income. The results reveal that the per capita disposable income of farmers participating in the farmer level CLI model is 38,870 yuan (USD 5,415) in the actual situation and 43,340 yuan (USD 6,038) in the counterfactual situation. The farmer level CLI model reduces the per capita disposable income of farmers participating in the model by 4,480 yuan (USD 624), but it fails the 10% statistical significance test. However, if farmers not participating in the farmer level CLI model participate in the model, the per capita disposable income will increase from 23,060 yuan

TABLE 3 Test of the average treatment effect of farmers' decision-making of participating in the CLI model.

Farmers' participation in CLI model	Actual results (A)	Counterfactual results (B)	ATT C = A − B	ATU D = B − A
Participating	4.455	4.078	0.377	—
Not participating	2.311	4.668	—	2.357***

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.

TABLE 4 Robustness test of replace the dependent variable and replace the model.

Variables	Per capita agricultural and animal husbandry income			ERM model		
	Farmers' participate in CLI	Farmer's income effect		Farmers' participate in CLI	Farmer's income effect	
		Participating	Non-participating		Participating	Non-participating
Information cost	−0.366*** (0.051)			−0.357*** (0.051)		
Negotiation cost	0.364*** (0.049)			0.373*** (0.049)		
Execution cost	−0.007* (0.004)			−0.007* (0.004)		
Labor	0.136* (0.079)	−0.770** (0.319)	0.055 (0.114)	0.130 (0.080)	−0.877*** (0.243)	−0.076 (0.178)
Per capita land	0.013*** (0.003)	0.049*** (0.007)	0.045*** (0.005)	0.012*** (0.003)	0.056*** (0.005)	0.049*** (0.007)
Land fragmentation	−0.005*** (0.001)	−0.002 (0.007)	−0.005*** (0.001)	−0.004** (0.002)	−0.005 (0.005)	−0.005** (0.002)
Specialization level	0.013 (0.022)	−0.017 (0.026)	0.031 (0.030)	0.012 (0.020)	−0.015 (0.005)	−0.011 (0.047)
Farmers' breeding	0.460*** (0.177)	0.261 (0.722)	0.062 (0.235)	0.445** (0.176)	0.342 (0.551)	−0.027 (0.365)
Age	−0.009 (0.009)	0.065* (0.037)	−0.000 (0.013)	−0.008 (0.009)	0.069** (0.028)	−0.019 (0.020)
Education level	−0.058** (0.028)	0.127 (0.100)	0.086** (0.040)	−0.050* (0.028)	0.181** (0.076)	0.106* (0.062)
Politics status	0.289 (0.181)	0.097 (0.670)	0.101 (0.280)	0.301* (0.182)	0.189 (0.504)	0.018 (0.436)
Farmers' training	0.299* (0.181)	−0.068 (0.636)	−0.627* (0.326)	0.272 (0.181)	−0.032 (0.482)	−0.115 (0.509)
Farmers' cognition	0.137** (0.070)	−0.051 (0.279)	−0.040 (0.101)	0.115* (0.069)	−0.012 (0.212)	−0.009 (0.158)
Village income	0.097 (0.095)	−0.383 (0.321)	0.532*** (0.203)	0.095 (0.096)	−0.372 (0.245)	0.548* (0.318)
Village farms	−0.103 (0.203)	−2.638*** (0.849)	−0.739*** (0.250)	−0.141 (0.202)	−2.733*** (0.646)	−0.700* (0.390)
Village cooperatives	0.114 (0.164)	1.090 (0.675)	−0.359 (0.243)	0.118 (0.164)	1.357*** (0.514)	−0.268 (0.378)
Constant terms	−0.604 (0.636)	2.034 (2.544)	−0.024 (0.964)	−0.542 (0.635)	1.335 (1.902)	1.320 (1.502)
Region	Control	Control	Control	Control	Control	Control
N	615	231	384	615	231	384
$\ln \sigma_{\rho^0}^0$	—	—	0.701*** (0.037)	—	—	—
$\rho_{\mu^0}^0$	—	—	0.261** (0.127)	—	—	—
$\ln \sigma_{\rho^1}^1$	—	1.412*** (0.047)	—	—	—	—
$\rho_{\mu^1}^1$	—	−0.125 (0.171)	—	—	—	—
LR	4.49			—	—	—
Log likelihood	−1,665.386***			−1,776.4594***		

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.
The results in the table are regression parameters and (standard error).

(USD 3,212) to 45,270 yuan (USD 6,306), increasing by 22,221 yuan (USD 3,095), and it passes the 1% statistical significance test. It indicates that the farmer level CLI model does not play a significant role in promoting the income of participated farmers, but it has a significant positive effect on the income of non-participating farmers. Similarly, the "farmers-to-farm" level CLI model does not significantly promote the per capita disposable income of participated farmers, while for farmers who do not participate in the "farmers-to-farm" level CLI model, if they participate in the model, their per capita disposable income will increase from 23,110 yuan (USD 3,219) to 45,890 yuan (USD 6,393), increasing by 22,780 yuan (USD 3,174), and it passes the 1% significance test.

TABLE 5 Average treatment effect of replace the dependent variable and replace the model.

Farmers' participation in CLI model	Per capita agricultural and animal husbandry income				ERM model's ATT		
	Actual results (A)	Counterfactual results (B)	ATT C = A − B	ATU D = B − A	Marginal effect	Standard error	*Z*-value
Participating	3.139	3.718	0.578*		0.864	0.526	1.64
Not participating	1.635	3.623		1.988***	—	—	—

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.

TABLE 6 Heterogeneity test of farmer level and "farmers–to–farm" level CLI model.

	Farmer level CLI model			"Farmers–to–farm" level CLI model		
	Farmers' participate in CLI	Income effect of farmers		Farmers' participate in CLI	Income effect of farmers	
		Participating	Non–participating		Participating	Non–participating
Information cost	−0.245*** (0.063)			−0.583*** (0.086)		
Negotiation cost	0.276*** (0.055)			0.508*** (0.075)		
Execution cost	−0.009* (0.004)			−0.010 (0.009)		
Labor	0.080 (0.101)	−1.326** (0.564)	−0.059 (0.133)	0.351*** (0.128)	−0.520 (0.374)	−0.060 (0.132)
Per capita land	0.014*** (0.004)	0.069*** (0.016)	0.051*** (0.005)	0.020*** (0.004)	0.040*** (0.009)	0.050*** (0.005)
Land fragmentation	−0.005*** (0.002)	−0.011 (0.021)	−0.005*** (0.002)	−0.006*** (0.001)	0.008 (0.007)	−0.005*** (0.002)
Specialization level	0.011 (0.023)	−0.016 (0.027)	−0.005 (0.035)	−0.027 (0.109)	4.046*** (1.470)	−0.012 (0.035)
Farmers' breeding	1.712*** (0.362)	−2.714 (3.104)	0.226 (0.286)	−0.471* (0.251)	0.684 (0.768)	−0.054 (0.268)
Age	−0.006 (0.011)	0.104* (0.054)	−0.020 (0.015)	−0.034** (0.015)	−0.023 (0.048)	−0.020 (0.014)
Education level	−0.016 (0.033)	0.085 (0.153)	0.111** (0.046)	−0.170*** (0.050)	0.357*** (0.135)	0.102** (0.046)
Politics status	−0.132 (0.230)	0.241 (1.039)	0.021 (0.325)	0.976*** (0.299)	−1.227 (0.822)	0.036 (0.323)
Farmers' training	0.305 (0.220)	0.487 (0.949)	−0.094 (0.376)	0.383 (0.297)	−0.642 (0.796)	−0.099 (0.376)
Farmers' cognition	0.194** (0.084)	−0.522 (0.389)	−0.005 (0.118)	−0.022 (0.124)	0.347 (0.391)	−0.017 (0.117)
Village income	−0.073 (0.117)	−0.285 (0.495)	0.322** (0.149)	0.020*** (0.004)	0.473 (0.489)	0.574** (0.235)
Village farms	−0.284 (0.245)	−3.426*** (1.247)	−0.083 (0.365)	−0.167 (0.146)	−2.036* (1.201)	−0.704** (0.289)
Village cooperatives	−0.105 (0.202)	1.791* (1.055)	0.339 (0.288)	0.338 (0.283)	1.201 (0.894)	−0.251 (0.280)
Constant terms	−2.179** (0.862)	7.119 (5.006)	0.236 (1.069)	−0.061 (1.184)	−0.104 (3.574)	1.333 (1.112)
Region	Control	Control	Control	Control	Control	Control
N	498	114	384	501	117	384
$\ln \sigma_{\rho^0}^0$	—	—	0.857*** (0.039)	—	—	0.841*** (0.036)
$\rho_{\mu^0}^0$	—	—	0.512*** (0.189)	—	—	0.205 (0.158)
$\ln \sigma_{\rho^1}^1$	—	1.418*** (0.067)	—	—	1.284*** (0.068)	—
$\rho_{\mu^1}^1$	—	−0.117 (0.251)	—	—	−0.537** (0.225)	—
LR	6.09**			6.88**		
Log likelihood	−1,320.8505***			−1,261.4537***		

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.
The results in the table are regression parameters and (standard error).

TABLE 7 Average treatment effect of the farm level and "farmers–to–farm" level CLI model.

	Income effects of participating farmers			Income effects of non–participating farmers		
	Actual results (A)	Counterfactual results (B)	ATT C = A − B	Actual result (A)	Counterfactual results (B)	ATU D = B − A
Farmer level CLI model	3.887	4.334	−0.448	2.306	4.527	2.221***
"Farmers–to–farm" level CLI model	5.010	4.257	0.753	2.311	4.589	2.278***

*, **, and *** indicate the significance levels of 10%, 5%, and 1%, respectively.

4 Discussion

4.1 Transaction cost

The results highlight the importance of transaction costs, such as information search costs, negotiation costs, and execution costs, for farmers' participation in the CLI model. Compared with the simple cultivation of grain, the transaction costs of selling forage and purchasing manure significantly inhibit the farmer's decision-making with regard to participating in the CLI model. This finding supports the conclusions of previous studies: high transaction costs, such as information collection costs, inhibit the operation of crop–livestock integration without third-party organizations (Barkema, 1993). Asai et al. (2018) analyzed six pasture cases worldwide also found that information gathering costs, collective decision-making costs, and operational and monitoring costs are the critical factors that influence the formation of the crop–livestock integration model beyond the farm level. Gil et al. (2016) also found that supply chain infrastructure exerts a critical role in the early occurrence of CLI. Currently, China's livestock industry is dominated by large-scale and specialized farms, a scenario similar to that in North America (Russelle et al., 2007); therefore, livestock farms possess limited land. Moreover, China is a country that possesses more individuals than its land can sustain: the average farmland area per household is <6 mu (~0.4 hectare) (Qinghai, 2018). Therefore, it is difficult to determine the occurrence of farm-level CLI in China owing to the high transaction cost of farmland transfer (Biliang and Chen, 2008). Although this study has not explored the relationship between the transaction cost of farmland transfer and the occurrence of the CLI livestock farm level, the existing research proves this relationship: Asai et al. (2014) found that livestock farmers are subjected to high-level competition in gaining access to crop farmer farmland. Therefore, the beyond-farm-level CLI is an inevitable choice for some livestock farms in China. The transaction cost, such as information cost, negotiation cost, and execution cost, between the livestock farm and the farmer are the key obstacles for restraining the occurrence of the beyond-farm-level CLI model.

4.2 Farmland scale and fragmentation

The result indicated that farmers' per capita farmland significantly promoted farmers' CLI participation, whereas the level of household's farmland fragmentation significantly inhibited farmers' participation. Qinghai (2021) also found that as of the end of 2016, there were 207.43 million agricultural households in China: only 3.98 million were large-scale agricultural households, and most of them are smallholder farmers, who cannot comprise the main CL body. Based on the farmer behavior theory, the expected economic benefit is the key factor for encouraging farmers to participate in eco-circular agriculture (Weihong et al., 2017). However, farmers with a low farmland scale and high fragmentation level can achieve neither economic of scale (Marshal, 1981) nor high economic benefit. Therefore, the farmland scale and fragmentation are the critical internal factors that influence farmer's decision-making in China.

4.3 Income effect

The CLI model's income effect results (Table 3) indicate that the CLI model significantly promotes the per capita disposable income of non-participated farmers, whereas the promotion effect on the participated farmer's income fails to pass the significance test. However, the robustness test results (Table 5) indicate that the CLI model significantly promotes the per capita agricultural and animal husbandry income of participated farmers, which is consistent with the results obtained by Xueting et al. (2020). The beyond-farm-level crop–livestock integration between potato and dairy farmers in Maine increased farmers' benefit: farmers could grow more profitable dairy forage crops in the short term (Asai et al., 2018). Additionally, fertilizer and pesticide use decreased, input costs reduced, revenues increased owing to expansion and increasing yields, and profitability increased in the long term (Hoshide et al., 2006). Therefore, the mixed agricultural system can enhance productivity and land use efficiency (Franzluebbers, 2007), enhance farmers' profitability, achieve income diversification (Allen et al., 2007), and save the cost of external inputs, thereby enhancing economic benefits. Meanwhile, the system can also retain nutrients (Acosta-Martinez, 2004). However, the combined farming system pertaining to beyond-farm CLI, which can achieve immense benefit, depends on the trust relationship and distance between farm and farmers. Because the farmers are close neighbors (below 20 km), their relationship is the key factor for the establishment of trust and a long-term vision of mutually shared benefits; thus, potato and dairy farmers of Maine can actualize farm-to-farm crop–livestock integration (Files and Smith, 2001). Due to the high transaction costs between farms and farmers, and because the CLI subsidies favor farms and cooperatives rather than farmers in China (Hua et al., 2017), the scenario where combined farmers achieve high benefit is relatively difficult to achieve in China.

4.4 Research implications

The study mainly focuses on the influencing factors and income effects of the CLI model from the household level, and finds that transaction costs, farmland scale, and the fragmentation level are critical factors that influence farmers' decision-making pertaining to CLI participation. The study provides empirical evidence for the development of CLI in other countries that exhibit more individuals and less land. Therefore, based on the obtained results, this study proposes the following policy suggestions: first, optimize the CLI model incentive policy, incorporate farmers into the scope pertaining to the subsidy policy of the CLI model, enhance the economic benefits of farmers participating in the CLI model, and stimulate the enthusiasm of farmers participating in the CLI model. Second, utilize information networks and other technologies to build an information-sharing platform between farmers and farms; enhance the CLI model training mechanism; rationally plan the distance between new farms and villages; reduce the costs of information searching, negotiation, and execution faced by farmers; and promote farmers' enthusiasm for participation. Third, enhance the farmland transfer market, increase farmers' farmland scale, and reduce farmers' farmland fragmentation level.

5 Conclusions

Based on a total of 615 farmer households in 10 pilot counties of dairy breeding and planting integration in the east, middle, and west of Inner Mongolia, this paper uses the ESR model to empirically analyze the relationship among transaction costs, farmers' decision-making of participating in the CLI model, and income effects. The following conclusions are drawn: (1) Under the existing market environment, the proportion of farmers participating in the CLI model is 37.56% of the sample farmers. (2) There is a problem of sample self-selection in farmers' decision-making of participating in the CLI model. Transaction costs are the crucial factors affecting farmers' decision-making of participation. High costs of information searching, negotiation, and execution will inhibit farmers from participating in the CLI model. (3) The effect of the CLI model on the income of participated farmers is not significant. The per capita disposable income of farmers participating in the CLI model is 44,550 yuan (USD 6,206) in the actual situation and 40,780 yuan (USD 5,681) in the counterfactual situation. Participating in the CLI model only increases the per capita disposable income of farmers by 3,770 yuan (USD 525) and fails the statistical significance test. However, if the non-participating farmers participate in the CLI model, their disposable income will significantly increase. Moreover, there is no significant heterogeneity in the effects of the internal and external circular CLI models on farmers' income.

Based on the conclusions of this study, the crop-livestock integration can significantly improve the income of non-participating farmers. Transaction costs are the most significant resistance factor for farmers that inhibit their ability to participate in the crop-livestock integration (CLI). Therefore, In order to encourage a renaissance of CLI in China in the future, future research can focus on identifying pathways to reduce transaction costs for agricultural producers, particularly when it comes to participating in the digital economy and cooperative extension services. Future research also could focus on how CLI improves farmers' social capital not only in China but elsewhere around the world.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

WB: manuscript writing and statistical analysis. YW: significantly contributed in design of study and revise of the manuscript. HB: data collection and verification of submitted manuscripts. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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