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Pastoral Differentiations on WTA Valuation for Grassland Eco-Subsidy–Empirical Study of 410 Herder Households in Grass-Livestock Balance Sub-Policy Zones in Inner Mongolia, China

Jiayu Dong [1,*], Zimeng Ren [2], Xinling Zhang [1] and Xiaoling Liu [3]

[1] College of Economics and Management, Inner Mongolia Agricultural University, Hohhot 010018, Inner Mongolia, China; dongjy1973@163.com (J.D.); zhang65628@126.com (X.Z.)
[2] College of Economics and Management, Northeast Agricultural University, Harbin 150030, China; rentt0620@163.com
[3] Independent researcher, Bixby OK, USA 74008; lxlttb@gmail.com
* Correspondence: dongjy1973@163.com; Tel.: +86-136-2471-0301 (J.D.)

Abstract: China's Grassland Eco-Subsidy Program has been implemented since 2011 to protect and sustain grassland resources and improve the economic situation of herders. In this case study, we evaluated the policy from the perspective of pastoral differentiations and their willingness to accept (WTA) the eco-subsidy. Using the contingent valuation method (CVM), we interviewed 410 herder households in the grass-livestock balance sub-policy zones across Inner Mongolia, and examined how their horizontal and vertical differentiation affected their WTA and compensation expectations in a sorted Logistic model and a Tobit model, respectively. Our findings suggest that horizontal differentiation of herders (variations of income sources and employments) promoted the WTA for eco-subsidy and inhibited the increase of compensation expectations. A large vertical differentiation extent (income disparity) lowered the WTA but raised expectations for payment levels. Besides, factors such as operating pasture area, precipitation, and supervision intensity had significant impacts. Grazing income remained the primary income source for most herder households, reflecting the characteristics of "the rational economic man." Our results suggest a need for policy improvements to guide herders towards becoming "rational ecological men." By considering this differentiation, policymakers can better tailor the program to meet the needs and expectations of diverse herder households.

Keywords: willingness to accept compensation (WTA); expectation of compensation; horizontal/vertical differentiations of pastoral households

1. Introduction

Grasslands account for 40% of the world's land area excluding Antarctica and Greenland and support ~1 billion people's livelihood [1]. The grasslands of China are a vital ecological and social-economic resource, covering 40% of the national area and serving as an ecological barrier in the north and northwest border of China [1,2]. These grasslands have multiple functions, including adjusting climate, preserving water resources, fixing carbon and releasing oxygen, and mitigating wind and sand dusts [3]. They are also the essential resources for agricultural productions and home to millions of herders of diverse ethnic groups [2]. However, the deterioration of grassland is widespread and is believed to be associated with overgrazing and overexploitation, as well as climate change [4–6].

To address this issue, China has implemented various programs, including one of the largest-scale government-led pastoralist-focused payment-for-ecosystem-services (PES) scheme since 2011, with fund of tens of billions of dollars allocated for ten years and benefited 12 million herders and is currently in its third 5-year phase (Table 1) [7]. In this study, we used the terms "subsidy", "compensation", and "reward" interchangeably to refer to this policy or program being examined, as consistent to the various terminology found in the existing literature.

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This program pays herders for reducing their grazing intensity or cessation of grazing, thus with two policy zones: the grass-livestock balance zone and the grazing ban zone. Each sub policy zone has its own payment standard, with payments currently at 7.5 RMB/mu and 2.5 RMB/mu for grazing ban zones and grass-livestock balance zones, respectively (mu is the area unit, 1 mu equals 1/15 hectare), or ~$16/hectare and ~$5.5/hectare for the two zones. These payment levels are the same for phase 2 (2016-2020) and phase 3 (2021-2025), which increased from the original 6.5 RMB/mu for grazing ban zones and 1.5 RMB/mu for grass-livestock balance zones. Here we use "grass-livestock" and "forage-livestock" interchangeably to align with the terminology in the existing literature.

This grassland PES program in China is a significant effort to restore and sustain the grassland ecosystem and lift the poverty of herders. It is a commendable initiative that recognizes the value of grasslands in ecological and social-economic terms. However, further research is needed to evaluate the effectiveness of the program in achieving its goals and to address any potential unintended consequences.

Table 1. China's government-led Grassland PES program.

Phase	Years	Payment standard (RMB/mu)		Program extent	References
	5-yr cycle	Grazing ban zones	Grass-livestock balance zones		
Phase 1	2011 to 2015	6.5	1.5	8 provinces	[8]
Phase 2	2016 to 2020	7.5	2.5	13 provinces	[9]
Phase 3	2021 to 2025	7.5	2.5	13 provinces	[10]

Researches discussed the effectiveness of ecological subsidy program in China, specifically in relation to livestock reduction behavior. While the implementation of the first round of ecological subsidies in 2011 was positively received [11], other studies highlight that the effect of livestock reduction was not sustained and overgrazing has not completely ceased [3,12]. Despite the second round of compensation to improve payment standards, livestock reduction has not continued to decrease and has even rebounded in some areas [13,14]. Based on the experience of ecological compensation PES worldwide, reasonable compensation standard is necessary to motivate pastoral households to actively participate in ecological compensation programs and ensure their welfare [15]. It is also well recognized the disparity WTP (what the government is willing to pay) and WTA (what the herders are willing to accept), particularly in relation to non-market products such as ecological and environmental services [16]. The policy offers WTP to incentivize herders, but it is important to consider herders' WTA, whether they are willing to accept the incentive. Herders, as the providers of ecological services, rely heavily on the grasslands for their livelihood, making them the most impacted group by the PES schemes [17].

We believe that the willingness to accept compensation is a premise for livestock reduction behavior. The occurrence and extent of livestock reduction behavior depend on the satisfaction degree of the compensation. Therefore, it is of significance to analyze the influencing factors of the WTA for the compensation to inform and improve the program effectiveness, and encourage sustainable livestock reduction behavior.

Research work in this area has primarily focused on the calculation of compensation criteria, and the factors that influence the herders WTA. These factors include the estimation of livestock reduction loss, the education level of the herders, family income [18], joint grazing situation [19], herders' age and education level [20], family size [21], steppe type and ethnic group [22], precipitation [20], etc. The existing research has not yet reached a consensus on the factors influencing the willingness of herders to accept the subsidy. This suggests that further research is needed to better understand these factors and herders' decision-making processes, and how these factors can be addressed to improve the program. This also implies a diversity in herders' behavior and decision-making and "one-size-fits-all" and "top-down" single PES scheme may not be effective [23,24].

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In recent years, due to China's rapid urbanization and agricultural transformation, rural households have become increasingly differentiated and diverse, with significant economic and social heterogeneity [25]. Environmental and ecological regulations and policies also have effects on the diversification of China's rural areas [26]. Our surveys found that to meet their education, medical and other needs, pastoral households in the natural grassland area of Inner Mongolia are transferring to cities and towns, resulting in a trend of both pastoral and non-pastoral employment among traditional "pure" herders. Additionally, with the expansion of pasture trade and exchange after the completion of the second round of pasture use-right tenure, differences among pastoral households, grassland productivity, grazing skills and management ability have further increased, leading to employment diversification and income disparity. However, existing studies on the willingness to accept compensation have not taken these distinctions of herding households into the analytical framework, few studies have examined the role of differentiation of herding households in their WTA evaluations.

This study sampled pastoral households in four counties across west to east in Inner Mongolia, collected their experiences and opinions on WTA for grassland eco-subsidy, and analyzed the data using ordered Logistic (or Logit) and Tobit regression models to examine how pastoral households' differentiation and diversity affected their willingness to accept compensation. We also attempted to determine whether these effects were positive or negative, i.e., whether they promoted or hampered herders' willingness to accept compensation. Given the obvious differences in payment levels and grassland productivity, as well as herders' livelihood involved, we focused on the herders in the grass-livestock (or forage-livestock) balance sub-policy zones and their attitudes towards participating in the program and their livestock reduction behaviors. The sampled pastoralists in this paper were all from the grass-livestock balance zones. This research aims to better understand the program's long-term effects from herders' perspectives and identify opportunities to improve the program, particularly in terms of the increasing diversity of income and employment opportunities for herders and their WTA preferences. This paper contributes to the growing literature on PES programs and sustainable land use policies in general and provides insight into improving it.

2. Materials and Methods

2.1. Site Survey

We began visiting and interviewing the pastoral households in September 2019 and conducted follow-up surveys from May to August 2021. Our research area spanned four typical league cities in the Inner Mongolia Autonomous Region, including Ordos City, Ulanqab City, Xilin Gol League to Hulun Buir City. The climate type of the research area gradually transitions from arid to semi-arid and to sub-humid from west to east. The grassland type of the sample sites spans from southwest to northeast from desert steppe, typical steppe to lush meadow steppe, covering a wide range from southwest to northeast of Inner Mongolia.

The method we used consisted of random sampling, semi-open questionnaire survey, and interviews. After excluding invalid samples such as households with grazing ban grasslands, those who hired other herders for grazing, or those who rented out their pasture, we retained 410 valid samples, and the effective sample rate was 95.2%.

This paper distinguishes between two variables in assessing the willingness to accept (WTA): the willingness to accept compensation and the expectation of receiving compensation [15,27]. The former represents the behavioral intention of herders to participate in the eco-subsidy program, while the latter reflects the participation extent of herders. By analyzing these two aspects simultaneously, a complete WTA assessment can be made.

In this study, the willingness and expectation of compensation refer to the strong willingness of herders to reduce their livestock to a reasonable stocking rate and the minimum compensation they are willing to accept. The survey questionnaire design mainly included the following: 1) basic statistical characteristics of herders; 2) herders' willingness to reduce livestock; 3) pastoral

households' perceptions on ecological and livelihood risks; 4) The herders' willingness to receive compensation and the minimum amount of compensation they would accept.

This study employed the contingent valuation method (CVM) to test the minimum expected compensation in exchange for reducing livestock to the theoretical stocking rate. CMV is a survey-based technique used to value non-market public goods and services, such as environmental and natural resources, by constructing a hypothetical market survey of people's willingness to pay (WTP) or willingness to accept (WTA) [28,29] with typical stated preference value [30]. The semi-closed and repeated bidding methods were combined and applied in this study. We first confirmed the grassland area that the herder households had been granted the land tenure, then we simulated the real market environment as much as possible, so as to ensure that the herder had sufficient understanding of relevant background information and to overcome the information bias to the max extent. The herders were asked about their expected compensation amount if livestock reduction was required to maintain a reasonable stocking rate. During the survey, the reference ranges for selection were given, and we asked the herders to justify their selection, and a "bargain" was conducted until a minimum expectation was agreed upon. The reference ranges for selection were given as <= 3 RMB/mu, 4-10 RMB/mu, 11-15 RMB/mu, 16-20 RMB/mu, 21-25 RMB/mu, 26-30 RMB/mu, 30-40 RMB/mu, or > 40 RMB/mu.

2.2. Theoretical Basis

In this study, we have analyzed the herders' differentiations, essentially economic situations, in two dimensions: vertical and horizontal. Vertical distinctions represent the economic differences based on the income divergence among the herders, while horizontal differentiation is based on their employment distinctions or income sources [25]. Non-agricultural or off-farm employment provides herders with alternative sources of income and reduces their dependence on pastoral and agricultural work, thereby improving their anti-risk ability and survival chances to certain extent [30]. The pastoral households implementing the ecological incentive policy have gradually diverged into pure pastoral households and various types of part-time pastoral households, leading to an increase in non-pastoral employment and income [31]. Employment distinctions lead to a difference in the willingness to be compensated among herders, as those with less non-animal husbandry income are more dependent on grazing income and have a relatively low willingness to be compensated for downsize their livestock numbers, while those with more non-pastoral employment channels and stable income are more willing to be rewarded or compensated [30].

Compared to pure herding households, households with higher part-time employment appeared more flexible in their production decisions and were more likely to respond to livestock reduction decisions [30]. Moreover, they have more opportunities to get to know the background of environmental and ecological protection policies, with less "information asymmetry", and their environmental awareness could be higher than those pure herding households. Under the condition of giving a certain amount of economic compensation, the higher the degree of employment differentiation, the more willing these herders would have to participate in environmental protection incentives. Therefore, we proposed our first research hypothesis H1, stating that employment differentiation of pastoral households has a positive impact on their willingness to accept grassland eco-subsidy.

However, employment distinctions could lead to a gap in compensation expectations among pastoral households. Households with a small proportion of non-pastoral income tend to have higher compensation expectations, while those with a high proportion of non-pastoral employment tend to have lower compensation limits. Hence, we proposed our second research hypothesis H2, stating that employment differentiation of pastoral households has a negative effect on the expectation of the eco-subsidy.

The occupational divergence of pastoral households leads to the transfer of family labor force and capital to the non-pastoral fields, resulting in a decrease in the available labor force and capital for animal husbandry production. With how the limited funds of pastoral households being distributed in animal husbandry and non-pastoral fields, the vertical distinctions would proceed.

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Herding households in the forage-livestock balance area aim to maintain the livestock income against large natural and market fluctuations, thus reducing the scale of livestock and grazing could significantly incite serious risk perception. Hence, research hypotheses H3 and H4 were proposed, stating that vertical differentiation of herders had a negative effect on their willingness to be subsidized (H3) and a positive effect on the expected value of the eco-subsidy (H4).

In summary, we proposed four hypotheses regarding the WTA and expected compensation value:

H1: Horizontal or employment distinctions of herder households have a positive impact on their willingness to accept the eco-subsidy.

H2: Horizontal or employment distinctions of pastoral households have a negative effect on the expectation value for the subsidy.

H3: Vertical or income distinctions of herders has a negative effect on their willingness to be compensated for grassland ecology.

H4: Vertical or income distinctions of pastoral households have a positive effect on the expected value of grassland ecological subsidy.

2.3. Models

The two dependent variables of this study are the willingness to accept compensation and the expectation value of the compensation. To quantify the willingness to accept the subsidy under the existing program payment standards, we gave ordered numbers 0-4 as options (Table 2) in ordered Logistic model. The expectation of compensation was estimated in Tobit regression.

2.3.1. Ordered Logistic model for WTA

In the ordered Logistic model, the dependent variable was the willingness of pastoral households to accept compensation, which were classified into five situations: strongly unwilling, unwilling, no preference, willing, and strongly willing. These five ordered latent variable Z′ was used to establish the sorted Logistic model [32].

$$Z'_i = \alpha_i X_i + \beta_i \tag{1}$$

Where Z′ the latent variable, representing the willingness of herders to accept the subsidy, α_i the regression coefficients for X_i, X_i the ith explanatory variable that may affect the WTA, β_i the intercept of the regression. Z_i, as the observed WTA for herders, $Z_i = (0,1,2,3,4)$, determined by:

$$Z_i = \begin{cases} 0, & if\ z_i' \le \varepsilon_1 \\ 1, & if\ \varepsilon_1 < z_i' \le \varepsilon_2 \\ 2, & if\ \varepsilon_2 < z_i' \le \varepsilon_3 \\ 3, & if\ \varepsilon_3 < z_i' \le \varepsilon_4 \\ 4, & if\ z_i' > \varepsilon_4 \end{cases} \tag{2}$$

To have a strong correlation between Z_i and Z_i', the probability of Z_i is as below with F the cumulative distribution function (CDF) of β_i:

$$\begin{cases} p(z_i = 0|x_i, \sigma, \varepsilon) = F(\varepsilon_1 - \alpha_i z_i) \\ p(z_i = 1|x_i, \sigma, \varepsilon) = F(\varepsilon_2 - \alpha_i z_i) - F(\varepsilon_1 - \alpha_i z_i) \\ p(z_i = 2|x_i, \sigma, \varepsilon) = F(\varepsilon_3 - \alpha_i z_i) - F(\varepsilon_2 - \alpha_i z_i) \\ p(z_i = 3|x_i, \sigma, \varepsilon) = F(\varepsilon_4 - \alpha_i z_i) - F(\varepsilon_3 - \alpha_i z_i) \\ p(z_i = n|x_i, \sigma, \varepsilon) = 1 - F(\varepsilon_4 - \alpha_i z_i) \end{cases} \tag{3}$$

Assuming F follows Logit distribution and take the natural log to get:

$$Ln\left(\frac{p_i}{1 - p_i}\right) = \beta_i + \alpha_i x_i \tag{4}$$

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2.3.2. Tobit model for WTA Expectation Value

To estimate the expected value for herders' WTA, the dependent variable is typical censored data with left-side and right-side thresholds. Thus, OLS regression is unsuitable and we chose Tobit model for censored data [33]. Censoring occurs when the interested dependent variable is not fully observed, leading to incomplete information about its true value. In Tobit model, the dependent variable is roughly continuous in positive range, assumed to be have a normal distribution, but observations below or above a certain threshold is truncated. The estimation of Tobit regression, as below, involves maximizing the likelihood functions, taking into account of the censored observations. The provided regression coefficients indicate the direction and magnitude of the relationships between the predictors and the latent variable.

$$\begin{cases} y^* = \beta_0 + \sum_{i=1}^{n} \beta_i x_i + \mu_i \; i = 1, 2, 3, \cdots, n \\ y = \max(0, y^*) \end{cases} \quad (5)$$

Where y is observations, β_0 intercept; β_i coefficients; X_i explanatory variables, and μ_i random error.

2.3.3. Explanatory Variables

The core explanatory variables in this study are pastoral household distinctions. Based on the theoretical analysis above, we take horizontal differentiation (employment distinctions) and vertical differentiation (income distinctions) as indicators to measure pastoral household preferences. In this study, the proportion of household non-pastoral income was used to represent the employment distinctions of pastoral households, and the household annual net income in its natural log to represent the vertical distinctions [34–36].

2.3.4. Control Variables

The following characteristic parameters for each household were used as the control variables in the regression.

- Household head characteristics (age and education)
- Family structure (available workforce and grazing grassland area);
- Household location (distance to the local government, precipitation, grassland type)
- Grassland degradation perception
- Livelihood risk perception

The characteristics of household head, family structures, location and degradation and risk perceptions were selected as control variables. The main characteristics of the head of the household are the age of the head of the household. Generally speaking, the older the head of the household, the weaker labor ability, the stronger the willingness to accept compensation rather than expanding grazing scale.

The grazing area and the number of labor force represented the family characteristics. The herder households with large grazing areas were more willing to accept compensation, as indicated by the payment standard on the area basis. The more available workers, the more willingness to expand production, the less willingness to get paid to reduce the grazing intensity.

The distance from the government, precipitation and grassland type were used to characterize the location characteristics. Further away from the local government, more precipitation, and more productive grassland type would favor the grazing activities, thus have negative impact on the willingness to accept the subsidy.

The study included the assessment of risk perceptions among pastoralist households, specifically focusing on their perceptions of grassland degradation and livelihood risk. We hypothesized a stronger perception of degradation would lead to a higher willingness to be subsidized, while a stronger perception of livelihood risk associated with livestock reduction would result in a lower willingness to be subsidized. To measure these two perceptions, two questions were designed, represent two different types of risk perception.

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The risk perception of herders was categorized on a Likert scale of 1 to 5. Question 1 asked herders for "How do you think of the current grassland conditions in terms of degradation?" The perception of degradation risk of pastoralists was: 1 = no degradation, 2 = not serious, 3 = average, 4 = serious, 5 = extremely serious. Question 2 for herders' livelihood risk perception was phrased as: Under the existing eco-subsidy standards, do you think it is a risky behavior to get the subsidy in exchange for reducing livestock to the prescribed stocking rate? 1 = not risky, 2 = somewhat risky, 3 = average, 4 = risky, 5 = highly risky.

All the regressions were performed in Stata 14 software.

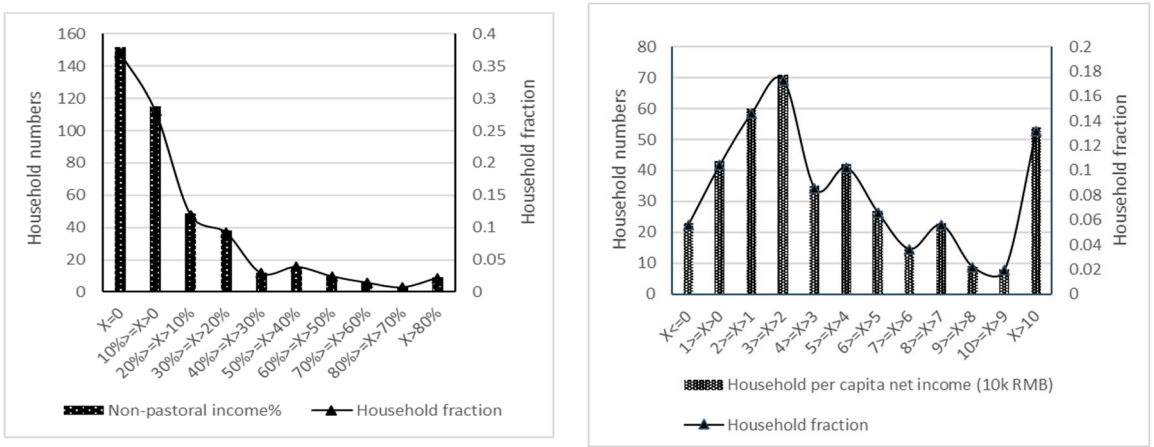
3. Results

3.1. Survey and Bargin Results

The survey revealed that the herders took the prescribed carrying capacity by the government as the reference point for their willingness and expectation to receive the compensation, and there was a large discrepancy in the willingness and expectation among herders. The minimum expectation to receive compensation was 7 RMB/mu, and the maximum was 50 RMB/mu. Some herders chose the minimum amount of compensation according to the subsidy level for the grazing ban areas, which was higher than the payment level for forage-livestock balance areas.

3.2. Horizontal and Vertical Distinctions among Herder Households

Based on our survey data, the distribution of herder households' horizontal/employment distinction and vertical/income distinctions are shown in Figure 1. The majority of the sampled households maintained a high dependance on livestock raising and grazing as their primary source of income. Off-farm income contributed to less than 20% of the total income for most of the households, approximately 90% of them. Per capita net income for nearly half of the households was less than 30k RMB, while ~13% of the households reported per capita net incomes exceeding 100k RMB. It is worth noting that ~6% of the households in debt to sustain their grazing practices. These findings highlighted a noticeable disparity in income, also as evidenced by substantial standard deviations in the data (Table 2).



(**a**) (**b**)

Figure 1. Histograms for the herder distributions of horizontal distinctions (X1) and vertical differentiation (X2', normalized per capita net income, not in natural log): (**a**) Herder distributions in various non-pastoral income percentage ranges; (**b**) Herder distributions in various household net income ranges. Net income was household gross income from all sources excluded the cost and taxes/fees. Per capita net income was shown as normalized based on each family size for a fair comparison across different family sizes.

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Table 2. Herder household WTA variables.

Variable	Description	mean	s.d.
Dependent variables			
WTA	Under the current subsidy payment level: 1 = strongly unwilling 2 = unwilling 3 = no preference 4 = willing 5 = strongly willing	3.22	0.813
EWTA	Expected subsidy (RMB/mu)	28.27	4.981
Explanatory variables			
X1	Horizontal/employment distinction = off-farm income/annual household net income	12.55%	0.197
X2	Vertical/Income distinction = Ln(annual household net income in 10k RMB) [30,36]	0.16	**9.648**
Variables related to X2	Annual household income (10k RMB)	18	19.2
	Persons/household	3.8	1.8
	Per capita income (10k RMB)	4.8	5.1
Control variables			
X3	Degradation perception: 1 = not degraded 2 = slightly degraded 3 = degraded 4 = severely degraded 5 = extremely degraded	2.47	1.056
X4	Livelihood risk perception for reducing livestock: 1 = no risk 2 = somewhat risky 3 = risky 4 = highly risky 5 = extremely risky	2.97	1.090
X5	Annual operating grassland area (hectare)	445.82	631.762
X6	Available family work force (persons)	2.11	0.863

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X7	Cumulative precipitation from last May to this July (mm)	460.53	116.269
X8	Household head age (years)	49.15	9.468
X9	Meat product avg. price (RMB)	764.44	381.826
X10	Supervision intensity 0 – loose 1 - strict	0.48	0.500
Type	Grassland type 1 = desert 2 = typical 3 = meadow	1.69	0.692

Data from authors' surveys and interviews.

3.3. Ordered Logistic Regression Results

The willingness in five orders had a mean of 3.22 (Table 2), slightly towards the willingness side, suggesting a marginal motivation to participate the PES scheme. The expectation was close to 30 RMB/mu (Table 2), more than 10-fold of the current payment level. The factors influencing the willingness to accept the subsidy were examined using the ordered Logistic model, and the results are presented in Table 3. The model accounted for approximately 19% of the variability in the dependent variable (Table 3). Among the selected explanatory variables, horizontal differentiation (X1), operating grassland area (X5), and household head age (X8) were found to be significant factors positively associated with herders' willingness to accept the subsidy. Conversely, vertical distinctions (X2), livelihood risk perception (X4), available work force (X6), precipitation (X7), and supervision intensity (X10) were found to have a negative association with the willingness to accept the subsidy.

Table 3. Ordered Logistic model output for herder households' WTA.

Variables		**Ordered Logistic Model**	**Robustness Test**	
		Base 410 households	**Ordered Probit Model**	**Ordered Logistic model for 375 households**
Horizontal diff.	X1	**1.691** **(0.005)*****	0.921 (0.010)***	1.331 (0.042)**
Vertical diff.	X2	**-0.024** **(0.020)****	-0.014 (0.015)**	-0.028 (0.010)***
Perception of degradation	X3	-0.085 (0.355)	-0.058 (0.280)	-0.139 (0.142)
Perception of livelihood risk	X4	**-0.217** **(0.022)****	-0.121 (0.026)**	-0.240 (0.021)**
Operating grassland area	X5	**0.003** **(0.000)*****	0.002 (0.000)***	0.004 (0.000)***
Available work force (persons)	X6	**-0.368** **(0.029)****	-0.219 (0.012)**	-0.395 (0.025)**
Precipitation	X7	**-0.004** **(0.000)*****	-0.002 (0.000)***	-0.005 (0.000)***
Household head age	X8	**0.031** **(0.014)****	0.017 (0.014)**	0.037 (0.006)***
Meat product price	X9	-0.0002	-0.0001	-0.0002

		(0.142)	(0.298)	(0.102)
Supervision intensity	X10	**-0.592**	-0.326	-0.603
		(0.004)* **	(0.005)***	(0.005)***
Grassland type	Type	0.199	0.107	0.206
		(0.223)	(0.244)	(0.228)
Pseudo R^2		0.1939	0.1901	0.1952

Note: (p-value): * < 0.1; ** < 0.05; *** < 0.01.

The employment distinction, or horizontal differentiation of pastoral households showed a positive correlation with their WTA and was statistically significant at the 1% level. A higher horizontal distinction, indicating a larger proportion of off-farm income, appeared to enhance the willingness to accept the subsidy. On the other hand, the income distinction exhibited a negative correlation with the willingness to accept the subsidy and was statistically significant at the 5% level. A greater vertical distinction, reflecting an increase in net income, resulted in a reduced willingness to accept the subsidy. As we observed earlier, for the sampled herder households in the forage-livestock balance areas, livestock grazing remained the primary source of income for most families. Consequently, these herders generally aimed to increase their income by expanding production. An increase in net income would heighten the desire and resources to expand livestock scale but diminish the willingness to accept compensation. Similarly, more available work force and more precipitation would negatively affect the willingness to take the subsidy and reduce livestock. Conversely, an aging household head and more operating grassland areas would favor the willingness to accept the subsidy.

Furthermore, livelihood risk perception significantly influenced the herders' willingness to accept the subsidy, with a higher risk perception weakening their willingness. Interestingly, pastoralists' perception of grassland degradation did not have a significant effect on their willingness to be subsidized. And with stricter supervision intensity, the willingness would be weakened.

3.4. Tobit Regression for Expected Value of the Subsidy

The factors influencing the expected value of subsidy accepted by pastoral households were examined using the Tobit regression model, and the results are presented in Table 4. Contrary to the correlation with WTA, but consistent with the interpretation of WTA, there appears to be a significant negative correlation between the horizontal distinction of pastoral households and the expectation of eco-subsidy, which is statistically significant at the 1% level. A greater horizontal distinction, indicating an increasing proportion of off-farm income, was associated with a decrease in the expectation of subsidy. On the other hand, the vertical distinction of pastoral households exhibited a significant positive correlation with the expected value of the subsidy, also significant at the 1% level. A larger vertical distinction, reflecting an increase in household net income, was associated with an increase in the expectation of subsidy. For households whose major income source comes from livestock production, compensation represents the expected loss resulting from reducing livestock to a prescribed or "reasonable stocking rate." The higher the net income, the greater the loss due to compensation, leading to a higher expectation for the subsidy.

Furthermore, operating pasture area, precipitation, and supervision intensity all had significant effects on the expected value of the subsidy, in the opposite direction to their effects observed for WTA, as expected. However, livelihood risk perception, household head age, and available work force did not show significance in this Tobit regression.

Therefore, our hypotheses H1 to H4 were supported, indicating that higher diversity in income sources or a larger proportion of income from off-farm employment would promote the herders' willingness to accept the subsidy, lower their subsidy expectations, while net income distinction would hinder their willingness to accept the subsidy and increase their expectation for the subsidy.

Table 4. Expectation value for the subsidy from Tobit model.

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Variables	Symbol	Estimated coefficient	S.E.	t- statistic	significance
Horizontal diff.	X1	**-4.981**	1.200	-4.15	**0.000*** **
Vertical diff.	X2	**0.080**	0.025	3.16	**0.002*** **
Degradation perception	X3	-0.101	0.230	-0.44	0.659
Livelihood risk perception	X4	-0.048	0.234	-0.20	0.839
Operating grassland area	X5	**-0.001**	0.0004	-2.23	**0.027****
Available work force (persons)	X6	0.410	0.288	1.43	0.155
Precipitation	X7	**0.007**	0.002	3.13	**0.002*** **
Household head age	X8	-0.024	0.025	-0.96	0.338
Meat product price	X9	0.001	0.001	1.24	0.215
Supervision intensity	X10	**1.308**	0.483	2.71	**0.007*** **
Grassland type	type	-0.609	0.367	-1.66	0.098
Constant	C	**26.521**	1.951	13.60	**0.000*** **

Note: (p-value): * < 0.1; ** < 0.05; *** < 0.01.

3.5. Multicollinearity and Correlation Test

Prior to conducting regression models, we performed multicollinearity and correlation tests among the variables. The results of multicollinearity test indicated that the independent variables had a maximum variance inflation factor (VIF) of 1.51, with an average VIF of 1.22. These values are well below the recommendation threshold of 10. Furthermore, the VIF values for the 12 variables ranged between 1 and 1.6, and the tolerance of each variable was close to 0, suggesting the absence of any multicollinearity issues.

Additionally, Pearson's test results revealed that both horizontal distinctions and vertical distinctions significantly influenced the willingness to accept and expectation value of the subsidy. These findings provided a solid basis for conducting further empirical analysis.

3.6. Robustness Test

To ensure the reliability of the results obtained from the benchmark model consisting of 410 household model (as shown in Table 3), two robustness tests were performed. First, the ordered Logistic model was substituted with the ordered Probit model, and the model outcomes remained largely consistent (refer to Table 3). Additionally, a robustness test was conducted after removing ~10% of abnormal samples, and the results of this test showed no significant alternations.

To guarantee the reliability of the Tobit regression model results presented in Table 4, the same robustness test was performed by excluding ~10% of the sample households. Although these specific results are not shown, they indicate that no significant changes occurred, thereby affirming the reliability of both the ordered logistic model and censored Tobit model.

In summary, the implementation of these robustness tests served to ensure the credibility and consistency of the model results.

3.7. An estimate of the Expected Value of Compensation

We employed a non-parametric estimation method to calculate the average expected value of the subsidy for the sampled pastoral households in the forage-livestock balance area, which was determined to be 28.27 RMB/mu. Besides, we introduced the parameter estimation method, based on the coefficients obtained from the Tobit regression, and by excluding the factors that were found to be statistically insignificant, we derived the expected value function for the subsidy that the pastoral households were willing to accept, which was presented as follows:

$$WTA = 26.521 - 4.981X_1 + 0.080X_2 - 0.001X_5 + 0.007X_7 + 1.308X_{10} \quad (6)$$

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By substituting the means of the significant explanatory variables into Equation (6), an estimated value of 29.31 RMB/mu was obtained for the expectation subsidy for these pastoral households.

4. Discussion

From our herder households in the forage-livestock balance areas across Inner Mongolia, we observed noticeable horizontal and vertical distinctions in both income source and income amount (Figure 1). Most households heavily relied on grazing for their livelihood, about 90% households had less than 20% off-farm income, and reducing stocking rates could be perceived as a livelihood risk that they are hesitant to take showing as being unwilling to accept the eco-subsidy. The government statistics show that on national average each household had received nearly 1500 RMB as the subsidy income [10], based on our samples, the average household net income of 180 k RMB/household (Table 2), implying the subsidy income accounts for less than 1% in net income. The unwillingness particularly evident when the subsidy payment level falls far below their expectations of compensating their income loss and associated risks, in our estimation, about 30 RMB/mu (expectation for the subsidy payment) vs 2.5 RMB/mu (actual payment level), a disparity of more than 10-fold.

This substantial gap between the expected and actual payment levels highlights a major factor contributing to the reluctance of herder households to participate in the subsidy program. When the payment is perceived as insufficient to compensate for the potential income loss and risks associated with reducing livestock, herders are less inclined to accept the subsidy and make the necessary changes to their grazing practices. To enhance the effectiveness of the policy and encourage higher participation rates, it is crucial to consider aligning the subsidy payment more closely with the expectations and needs of herder households. Addressing this disparity and ensuring that the payment adequately reflects the income loss and risks can help improve the acceptance and compliance of the subsidy program.

In our ordered Logit model, eight explanatory viables showed significance. The variables with a positive effect were horizontal distinction (X1), operating grassland area (X5), and household head age (X8). With higher off-farm income, households relied less on grazing activities, and an increase in operating grassland area, which is directly linked to the subsidy income, resulted in a higher fraction of off-farm or non-grazing income. Furthermore, as the household head grew older, they tended to prefer off-farm income over labor-intensive grazing activities.

The variable with a negative effect in the ordered Logit model were vertical distinction (X2), perception of livelihood risk (X4), available work force (X6), precipitation (X7), and the supervision intensity (X10). A larger income disparity appeared to lower the willingness-to-accept (WTA) the subsidy, further emphasizing the heavy reliance on grazing as the primary income source for the majority of these households. When households had a larger available work force, they tended to increase their stocking and grazing activities to generate more income. Similarly, favorable natural conditions with increased precipitation, indicating greater availability of grass and forage, led to an inclination to increase stocking and grazing activities rather than reducing the stocking rates and accepting the subsidy, which was anticipated to be insufficient in compensating for their loss due to stocking reduction [19,37]. If participating the subsidy programs to reduce the stocking means a great livelihood risk, these household would lower their willingness to accept the subsidy. Interestingly, stricter supervision had a negative impact on herder households' willingness to accept the subsidy, suggesting that incentives need to be self-driven rather than imposed and we need to pay close attention to the participants and most-affected of the PES programs – the herders.

These findings highlight the importance of considering economic, demographic factors and the size of the operating grassland area when designing and implementing subsidy programs, as they significantly influence the willingness of herder households to participate and make changes to their livestock management practices.

When estimating the herders' expectation for the subsidy, the number of significant explanatory variables decreased from 8 to 5, and they are employment distinctions (X1) and operating grassland area(X5), both with a negative effect, and net income distinctions (X2), precipitation (X7), and

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supervision intensity (X10), with a positive effect. The directions of these variables were opposite to their effect on WTA in the ordered Logit model, thus supporting our hypotheses. The dropped variables were perception of livelihood risk (X4), available work force (X6) and household head age (X8). Therefore, the hypothesized horizontal and vertical distinctions were significant in both models. The grassland area, precipitation, and supervision intensity, combined with the identified economic distinctions, played a role in both models. The estimated expectations we obtained are more than 10 times the current payment level for the forage-livestock balance sub-policy zones. Other studies have indicated a wide range of WTA expectations for higher policy compliance using various methods [18,38,39]. While we acknowledge the potential benefits of increasing the payment level, we also recognize that it may not practical to significantly raise the payment level, especially not in near future or by more than 10-fold. Therefore, we suggest considering alternatives to enhance the policy effectiveness.

The theory of forage and livestock, or grass and grazing balance tries to promote livestock reduction through the ecological compensation policy. However, the effective transmission of this policy to livestock reduction has been lacking. Survey findings indicate that when asked about livestock reduction, herders often referred to "empirical stocking rate" as the benchmark, similar to the "desirable stocking rate" concept [40], and believed that reducing breeding scale to match this rate does not negatively impact the ecological function of the grasslands. When expressing their intention to be compensated, the herders naturally shifted their reference point to the "reasonable loading rate" set by the government. They consider reducing to the loading rate as the criteria for qualifying for the subsidy. However, the herders' actual loading rate was often much higher than the stipulated reasonable loading rate, especially for herders who had small- or medium-scale operating grassland [41].

Consistent with our previous study [20], the herders' vague understanding of grassland ecology and their deviation from the equilibrium theory, which forms the basis for the eco-subsidy policy, pose challenges in effectively promoting the policy. Unfortunately, our survey uncovered instances of distorted policy implementation where certain herders utilized the subsidy income as a production fund to acquire additional livestock, similar to findings in other studies [14,26,42–44]. The herders' understanding of non-equilibrium ecological theory is reflected in their empirical stocking rates based on their adaptations to the natural conditions. They believed that a flexible stocking rate, determined by factors such as climate change, is crucial for making decisions about livestock scale while the "reasonable loading rate" is a fixed rate established by government agencies according to the stocking density prescribed by balance theory. Furthermore, the policy applies a single fixed "reasonable loading rate" across a region without considering the differentiation among herder households, including factors such as their grassland areas with use right tenure. For instance, research has shown that small- and medium-scale grassland users tend to experience more severe overgrazing compared to large-scale grassland users and subsidy shall not be linked to the grassland areas [41,45]. Studies also suggest a mixed features of equilibrium and non-equilibrium theories in natural grasslands [46,47], such differentiation shall also be taken into account rather than a single top-down stocking rate grazing management.

Since the herder households are the most effected groups by the policy and our findings suggest that we need to consider their distinctions in their off-farm employment and their income levels, provide them with off-farm employment skills and more efficient livestock production, and also allow them the stewardship of grasslands. Scholars advocate differentiation in payment levels and a bottom-up approach instead to promote an active role of herders in the implementation of the PES schemes, and to motivate them to participate in the grassland rehabilitation and their livelihood improvement [1,48].

Let us take a look at another hypothesis of herders as the "rational economic man" that also form the eco-subsidy policy basis. In this theory, herders are assumed to be motivated by self-interest and make decisions to maximize their economic utilities. In contrast, ecological and economical rationality suggests that farmers and herders in the ecological economic systems not only consider the economic rationality of "cost-benefit" but also have ecological rationality in pursuing ecological

value [49,50]. Their environmental perception could significantly lower their expectation of WTA [48]. The rational ecological man would recognize the human well-being is interconnected with the health of natural environment. Here economic and ecological rationalities are not mutually exclusive; rather, they constitute essential components of a comprehensive, multi-dimensional decision-making process. Ecological rationality suggests that individuals make decisions that are not only economically rational but also environmentally sustainable. It takes into account the long-term impacts on ecological systems and promotes the decision-making that aligns with ecological principles. Economic conditions determine economic rationality, and the transition from economic rationality to ecological rationality is only feasible when farmers and herders have improved livelihood conversion ability [51], with more efficient livestock production, multiple income sources, and more off-farm employment opportunities. As ecological prioritization becomes the guiding strategy for animal husbandry production systems, educating and guiding herders to shift their ecological understanding to incorporate balance theory may help for effective policy implementation.

5. Conclusions

Based on the empirical analysis of 410 herder households' willingness and expectation in the forage-livestock balance area in natural grasslands in Inner Mongolia, this study reveals the impact of herders' differentiations on their willingness to accept the subsidy. The following key findings and recommendations are highlighted:

(1) Employment or horizontal differentiation of pastoral households had a significant positive impact on the willingness to accept the subsidy and a negative impact on the expectation of compensation, while net income or vertical differentiation showed the opposite pattern.

(2) The current grassland eco-subsidy payment standard appeared to be low and insufficient to match the herders' WTA expectation. The acceptable range for herders in the forage-livestock balance area was estimated to be between 28.27 RMB/mu to 29.31 RMB/mu. The low compensation standards fail to motivate herders who heavily rely on animal husbandry as their main source of income, and limited non-animal husbandry employment options hinder their willingness to accept.

Based on these findings, the following recommendations are proposed:

Enhance the subsidy standard and improve the livelihood conversion ability of pastoral households: Given the substantial gap between herders' willingness to accept the subsidy and the current payment standard, it is necessary to moderately increase the payment standard. Moreover, a shift from a single subsidy mode is recommended to encourage continued and deepened livestock reduction behavior among herders to address their distinctions and diversity. Furthermore, it is crucial to strengthen non-pastoral skills training, particularly targeting young and middle-aged herders, to expand non-pastoral employment opportunities and enhance their livelihood conversion ability.

Shift the policy from top-down to bottom-up and guide herders to become "ecologically rational people" based on ecological priority strategy and allow them a more active role in the policy. By coordinating different policies and adopting an ecological priority strategy, herders' awareness of ecological protection could be enhanced, along with their understanding of ecological and environmental risks, thereby increasing their willingness to accept compensation. Encouraging herders' active participation in grassland ecological and environmental protection would empower them as key contributors to the preservation of grassland ecosystems.

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