

Article

The Impact of Informal Learning on Herders' Operating Income: An Analysis Based on Human Capital Differences

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Abstract: Improving the operating income of farmers and herdsmen is an important starting point for achieving common prosperity. As a common form of learning and an important source of skills training, informal learning has a certain impact on the economy and income level of farmers and herdsmen. This paper takes 439 herdsmen in three cities of the Inner Mongolia Autonomous Region as the research object and tries to explore the comprehensive influence, subdivision difference, and mechanism of informal learning on the operating income of herdsmen on the theoretical and empirical levels. The results show that the impact of informal learning on the operating income of herdsmen is “inverted U-shaped”, and there is an informal learning balance point of 2.9776 h, which maximizes the effect of informal learning on the increased operating income of herdsmen. After using the instrumental variable method to deal with endogeneity and conducting robustness tests through winsorizing, quantile regression, and substitution variables, the research conclusions were still valid. Heterogeneity analysis found that informal learning has a significant impact on the increase in operating income of herdsmen in the low human capital group, reflecting the role of “sending charcoal in the snow”. However, it has no significant effect on the increase in operating income of herdsmen in the high human capital group, and the effect of “icing on the cake” is not obvious. In view of this result, government departments should speed up the planning of Internet infrastructure construction in pastoral areas, and accurately push the knowledge and skills needs of herdsmen to help increase the operating income of herdsmen.

Keywords: informal learning; herders' operating income; heterogeneity human capital; “inverted U-shaped” curve



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1. Introduction

Ensuring the growth of rural residents' income is the key to achieving common prosperity for all in China [1], and it is also the focus and difficulty of implementing the rural revitalization strategy [2]. In 2023, the “Central No. 1” document proposed to promote the efficiency of agricultural operations, and drive rural residents to achieve cost efficiency, quality efficiency, and marketing efficiency. It is an important task to effectively ensure the continuous increase in rural residents' income on the existing basis [3], which is even more difficult for herdsmen in grassland pastoral areas [4].

Influenced by human capital, social capital, and other factors, operating income is still an important source of household income in pastoral areas [5–8], accounting for 63.07% of total household income (operating income of farmers accounts for 34.69% of total household income). (The data are from the 2021 *Xilingol League Statistical Yearbook* and the 2022 *China Rural Statistical Yearbook*. The Xilingol League includes 13 counties (districts), of which 10 counties (districts) are animal husbandry and semi-animal husbandry counties, accounting for 30.30% of Inner Mongolia's animal husbandry and semi-animal husbandry

counties. The data are typical and representative). Existing studies have found that the increase in herdsmen's operating income is affected by the external environment such as policy support, brand building, digital empowerment, and financial supply [9]. On the other hand, it is closely related to its internal characteristics such as social capital and resource endowment [10,11]. In addition, Jiang et al. (2021) pointed out that the path of increasing income by improving the level of human capital is equally important [12].

Learning is a way to improve the level of human capital, including formal learning and informal learning [13]. Formal learning is described as highly structured learning, that is, learning in the curriculum, classroom, and school [14]. In practice, it is often manifested as education and training organized by grassroots governments. Although formal learning activities have a significant role in promoting the improvement of agricultural production efficiency and the increase in operating income [15–17], due to the vast territory of China [18], the scattered residence of herdsmen [19], and the shortage of grassroots funds [20,21], formal learning is not effective [22,23]. In addition, there are also deficiencies in formal learning, such as elite capture and the imbalance between supply and demand [24,25].

As a supplement to formal learning [26], informal learning has no clear time, place, or curriculum objectives [27], thus breaking the time and space constraints, promoting the exchange and sharing of information and experience, enabling demand-oriented situational learning to be realized, and gradually becoming a common form of adult learning [28] and an important source of skills development [29].

Informal learning has a good landing environment in pastoral areas of China. The Internet usage environment in pastoral areas continues to improve. On the one hand, we will vigorously promote the construction of an information infrastructure and the popularization of informatization, accelerate the layout of 5G construction, and focus on improving the Internet arrival rate and coverage in remote areas. On the other hand, the implementation of the Inner Mongolia Radio and Television Bureau pastoral area intelligent radio and television broadband network coverage and service project, will improve the broadband network access capability. By 2022, Inner Mongolia had built a total of 20,163 5G base stations and had achieved more than 20 megabits of broadband network access for the most remote and scattered herdsmen in 124,000 pastoral areas (Data from: a. Learning Powerful Country, the URL link is as follows: https://www.xuexi.cn/lcpage/detail/index.html?id=13762307172967271025&item_id=13762307172967271025 (accessed on 29 July 2023); b. National Radio and Television Administration, the URL link is as follows: http://www.nrta.gov.cn/art/2022/7/11/art_114_60925.html (accessed on 29 July 2023)).

Herdsmen's acceptance of Internet applications has increased. With the advent of the era of self-media and the popularity of smartphones, pastoralists' access to information and active learning methods has changed dramatically [30]. In addition, due to the global changes caused by COVID-19, teaching and learning have gradually shifted from the traditional way to the online way [31], and the status of providing teaching resources through self-media has become increasingly apparent [32]. In 2023, the "China Internet Development Statistics Report" pointed out that the popularity of rural Internet applications has accelerated, and the short-video usage rate of rural Internet users has exceeded that of urban Internet users by 0.3%. The supply of digital services such as online education is also increasing. Online education users in rural areas account for 31.8% of rural Internet users.

The content supply of agricultural technology knowledge has gradually diversified. According to the "Tik Tok Agricultural Technology Knowledge Data Report" in 2022, the annual growth rate of agricultural planting, breeding, and agricultural machinery content submissions is 50.4%, and the average daily agricultural technology short-video playback rate can reach 1 billion times. Accordingly, self-media short videos have gradually become the most important way for herdsmen to conduct informal learning.

So, what is the impact of informal learning on the operating income of herdsmen? Under the different human capital levels of herdsmen, we wish to explore whether there

is a difference in the impact of informal learning on the operating income of herdsmen, that is, the high human capital herdsmen “icing on the cake” and the low human capital herdsmen “charcoal in the snow”. It is of great theoretical and practical significance to explore the above problems and explore the relevant policy optimization path to improve the communication network capacity of pastoral areas and increase the operating income of herdsmen in China.

Based on this, this paper takes the micro survey data of the Xilingol League, Ulanqab City, and Ordos City as the data source, uses OLS and 2SLS methods to empirically verify the influence mechanism of informal learning on the operating income of herdsmen, and explores whether there is a balance point of informal learning time, to maximize the effect of informal learning on the increase in operating income of herdsmen. Furthermore, we analyze the effect of heterogeneous human capital on the increase in herdsmen's operating income.

The marginal contribution of this paper is mainly manifested in the following aspects: firstly, most of the existing literature focuses on the impact of formal learning on income, and few works of literature discuss the mechanism of informal learning on income. Secondly, this paper discusses the differences in the impact of informal learning on different human capital in groups and provides new ideas for diversified countermeasures. Thirdly, this paper considers the “inverted U-shaped” relationship between informal learning and herdsmen's operating income, and more accurately reveals the effect of informal learning on herdsmen's operating income.

2. Theoretical Analysis and Research Hypothesis

2.1. *The “Inverted U-Shaped” Curve of the Impact of Informal Learning on Pastoral Households' Operating Income*

The information effect theory holds that the degree of information acquisition and mastery will affect the individual's decision-making behavior [33], and the degree of information acquisition and mastery is determined by information search behavior. Herdsmen's information search behavior is affected by search costs [34,35]. If the search cost is too high, herdsmen will limit their search behavior and make production decisions under limited information conditions. On the contrary, if the search cost is low then herders will increase the degree of information search and further optimize the allocation of resources. As the most important way of informal learning, self-media short-video communication helps to promote the independent provision and sharing of information [36], reducing the search cost for herdsmen for animal husbandry production information. In addition, learning requires a connection between language and images [37]. The cognitive theory of multimedia learning points out that the learning effect is best when both visual and auditory information is used to a similar extent [38]. Teaching videos help learners select relevant learning content from learning materials and promote the association between new knowledge and prior knowledge by integrating various information such as language and vision [39]. Therefore, through self-learning via the self-media short video, herdsmen can not only realize the effective connection between production demand and learning information supply, but also improve their cognition of new knowledge and skills. In turn, it may promote to herdsmen the adoption of new breeding technologies, improve production efficiency, and increase operating income.

To increase user stickiness, self-media short-video applications will predict users' personal preferences through recommendation algorithms and push homogeneous information with similar themes and similar plots [40]. At this time, even if the herdsmen spend more time on self-media short-video learning, the acquired knowledge may be the same type and the information is homogenous. Although the cost of the information search is greatly reduced, video homogenization weakens the information utility. Therefore, when herdsmen spend less time on self-media short-video learning, herdsmen can learn more agricultural knowledge and agricultural and animal husbandry production information, which is more conducive to herdsmen improving production efficiency and increasing

their operating income. When the time invested by herdsmen in self-media short-video learning exceeds a certain time threshold, the user's personal preferences are amplified and solidified by the recommendation algorithm, which will lead to homogenous short video content that users are exposed to and the relevant knowledge that herdsmen can learn is reduced, and the improvement effect on the operating income of herdsmen will be weakened.

Based on the above analysis, the following hypothesis is proposed:

H1. *The impact of informal learning on the growth of herdsmen's operating income is "inverted U-shaped". There is a learning time balance point to maximize the effect of informal learning on increasing herdsmen's income.*

2.2. The Mechanism of Heterogeneous Human Capital Affecting the Learning Time Balance Point

The knowledge conversion of herders depends on their human capital endowment and learning autonomy [41]. Knowledge, skills, and health are the basic variables to measure human capital [42,43]. Existing studies have shown that Internet information technology has a more obvious impact on groups with higher education, higher labor skills, and better health [44]. The higher the human capital endowment of the herdsmen, the better the absorption effect of the learned knowledge of animal husbandry production [45]. It is more likely to optimize the input of production factors by adjusting and correcting early production experience and habits [46], so that informal learning has a more obvious effect on income, showing a trend of "icing on the cake". If the human capital endowment of herdsmen is weak, their actual technical level, animal husbandry technology adoption, and transformation efficiency are low [47]. Informal learning not only improves the level of herdsmen's human capital [48] but also broadens the channels for herdsmen to obtain animal husbandry information and learn relevant production technologies [49], thus improving labor productivity and promoting the increase in operating income.

Based on the above analysis, the following hypothesis is proposed:

H2. *The impact of informal learning on pastoral households' operating income varies due to differences in human capital.*

3. Data and Methods

3.1. Data Sources

The data of this paper are derived from the household questionnaire survey conducted by the research group in the Xilingol League, Ulanqab City, and Ordos City of the Inner Mongolia Autonomous Region from November to December 2021. On the one hand, as one of the five major pastoral areas in China, the Inner Mongolia Autonomous Region is the largest provincial-level administrative region in China, with a linear distance of more than 2400 km from east to west. The three selected leagues and cities cover the eastern, central, and western regions of Inner Mongolia, with sampling representativeness, and can show the overall situation of pastoral areas. On the other hand, with the continuous advancement of the modernization of pastoral areas and the implementation of the broadband network coverage and service project of "smart radio and television" in pastoral areas, the communication network capacity of pastoral areas in Inner Mongolia has been significantly improved, and the network environment for herdsmen to carry out informal learning has been significantly improved.

The survey adopted a stratified sampling method. First of all, the research group comprehensively considered the population situation, grassland status, and regional economic development level of pastoral areas, and selected the Xilingol League, Ulanqab City, and Ordos City as sample leagues (cities). Secondly, 1–3 flags (counties) in each league (city) and 1–3 townships (Sumus) in each banner (county) were selected. Finally, in each township (Sumu) according to the income of the high, medium, and low levels, a random sampling of 20–30 herdsmen was conducted for a household survey. According to the above sampling method, 464 herdsmen were interviewed in this survey. After sorting out and analyzing,

439 valid questionnaires were obtained after eliminating invalid questionnaires for reasons such as inconsistency and lack of key information, and the effective response rate of the questionnaire was 94.61%. Table 1 presents the regional distribution of samples.

Table 1. Regional distribution of samples.

Sample Union (City)	Sample Flag (County)	Sample Size
Xilingol League	Xilinhot City	54
	Plain and Bordered White Banner	59
	Sonid Left Banner	66
Ulanqab City	Siziwang Banner	57
	Otog Banner	92
Ordos City	Hangjin Banner	60
	Uxin Banner	51

3.2. Method and Model Specification

To investigate the impact of informal learning on the operating income of herdsmen, this paper sets up a regression model that includes both the one-time term and the square term of informal learning time. The basic expression is as follows:

$$\ln OI_i = \beta_0 + \beta_1 LT_i + \beta_2 LT_i^2 + \beta_3 X_i + \varepsilon_i \quad (1)$$

Among them, the explained variable $\ln OI_i$ is the logarithm of the operating income of “i” herders. The core explanatory variable LT_i , LT_i^2 represents the length of informal learning of “i” herdsman and its square term. X_i represents the control variables, including the head of household characteristics, family characteristics, and so on. β_i is the parameter to be estimated. ε_i is a random disturbance term.

3.3. Variable Description and Descriptive Statistical Analysis

3.3.1. Explained Variable

The explained variable of this study is the annual animal husbandry operating income of herdsmen in 2020, mainly including the sales income of livestock (by-products) such as beef and mutton, dairy products, animal fur, and cattle and sheep manure (fuel) [50,51]. To reduce the influence of heteroscedasticity, the operating income takes the logarithmic form.

3.3.2. Core Explanatory Variable

The main explanatory variable of this study is the informal learning of herdsmen through self-media short videos. The duration of informal learning was characterized by the average length of time for herdsmen to understand and learn information about animal husbandry production through self-media short videos every day throughout the year. This variable is continuous.

3.3.3. Instrumental Variable

There may be a reverse causal relationship between the explanatory variables and the core explanatory variables, that is, while informal learning affects the operating income of herdsmen, the amount of operating income of herdsmen may in turn affect their ability to conduct informal learning. This will lead to biased estimation results of the model. Therefore, the distance between the herdsman’s family and the nearest signal tower is selected as the instrumental variable to solve the endogenous problem. It is generally believed that instrumental variables should meet two requirements: exclusiveness and relevance. On the one hand, this instrumental variable does not directly affect the increase in herdsmen’s operating income. It is exogenous and meets the exclusive requirements of instrumental variables. On the other hand, this instrumental variable is closely related to whether the herders conduct informal learning behavior, which meets the correlation requirements of the instrumental variable. The reception and transmission of mobile phone

signals are completed by the mobile signal tower. The farther the distance between the herder's family and the nearest signal tower, the worse the quality and stability of the network, and the smaller the possibility or learning time of the informal learning of the herder. Because herdsmen need to spend more time, energy, and information costs to conduct informal learning in an environment with weak network signals, it is less possible to obtain relevant information and services for informal learning. This variable is an ordered categorical variable. The distance between the herdsman's family and the nearest signal tower greater than 12 km is assigned to 1. The distance greater than or equal to 9 km and less than 12 km is assigned to 2. The distance greater than or equal to 6 km and less than 9 km is assigned to 3. The distance greater than or equal to 3 km and less than 6 km is assigned to 4. The distance less than 3 km is assigned to 5.

3.3.4. Control Variable

Referring to the existing research experience and combining with the research purpose, this study selects variables such as the characteristics of the pastoral household head and family characteristics as control variables. Among them, the characteristics of the head of the household select the household head's age, sexuality, marital status, years of education, whether a member of a village cadre, the number of times of receiving production technology training, and other variables; family characteristics select variables such as the number of the family labor force, the scale of grassland management, the expenditure of human gifts, and the distance from the local government [52–56]. At the same time, the variable of human gift expenditure is logarithmically processed.

3.3.5. Grouping Variable

The grouping variable of this study is the head of household human capital. The head of the household is the main decision-maker in the family, and the level of human capital is the key factor affecting the production and living conditions of the family [57]. Table 2 presents the calculation methods for the above variables.

3.3.6. Descriptive Statistical Analysis

Table 3 presents the essential statistical characteristics of the main variables. The mean value of the logarithmic form of the operating income of the herdsmen is 11.69 and the standard deviation is 1.11. The mean value of the scale of grassland management is 341.1749 hectares and the standard deviation is 750.7325. This shows that the sample covers not only the local high, medium, and low-income groups but also the herdsmen of different grassland scales, which can reflect the actual situation of the pastoral area relatively comprehensively [58]. Among the core explanatory variables, the average daily informal learning time of herders is 0.97 h, indicating that some herders have an awareness of informal learning and have learned information and knowledge related to animal husbandry production through self-media short videos. From the perspective of the characteristics of the head of household, the average age of the surveyed herdsmen is 51 years old, and most of the surveyed herdsmen are 38–62 years old. The average years of education is 8.16 years, but most herdsmen have under 9 years' education, and the overall cultural level of herdsmen is low.

Table 2. Definition of main variables.

Variable Category	Variable Name	Variable Symbol	Definition
Explained variable	Operating income	OI	The annual income of herdsmen's animal husbandry, taken as the logarithm
Core explanatory variable	Length of informal learning	LT	The average length of time for herdsmen to understand and learn information about animal husbandry production through self-media short videos every day throughout the year (hours)

Table 2. Cont.

Variable Category	Variable Name	Variable Symbol	Definition
Instrumental variable	Distance from the nearest signal tower	Dis1	The distance between the residence and the nearest signal tower, very far = 1; far = 2; medium = 3; close = 4; very close = 5
Individual characteristics	Age	Age	Age of household head (years)
	Sexuality	Sex	Sexuality of household head, male = 1; female = 0
	Marital status	Mar	The marital status of the household head, married = 1; unmarried = 0
	Education	Edu	Years of education of household head (years)
	Village cadres	VC	Whether a member of a village cadre, yes = 1; no = 0
Family characteristics	Production technology training	Train	The number of production technology training received throughout the year (times)
	Household labor force	LF	Number of the household labor force engaged in animal husbandry throughout the year (persons)
	The scale of grassland management	Area	The annual actual use of grassland area (hectare)
	Human gifts expenditure	Hge	Family annual human gifts expenditure, taken as the logarithm
	Distance from the local government	Dis2	The distance between the place of residence and the seat of the local government (kilometer)

Table 3. Descriptive statistics.

Variable Category	Variable	Obs	Mean.	Std. Dev.	Min	Max
Explained variable	OI	439	11.6905	1.1054	5.2983	13.9333
Core explanatory variable	LT	439	0.9730	1.0111	0	8
Instrumental variable	Dis1	439	3.4556	1.4294	1	5
Individual characteristics	Age	439	51.0774	10.3999	20	78
	Sex	439	0.8474	0.3600	0	1
	Mar	439	0.9522	0.2137	0	1
	Edu	439	8.1617	3.6237	0	19
	VC	439	0.0797	0.2712	0	1
Family characteristics	Train	439	0.8405	2.1932	0	30
	LF	439	2.2460	0.8405	1	6
	Area	439	341.1749	750.7325	12	12,000.006
	Hge	439	9.2501	0.8997	6.2146	11.2898
	Dis2	439	50.5416	43.4254	1	250

4. Results and Discussion

Based on the above analysis and assumptions, this paper used Stata 17.0 to estimate the model, and the results are as follows.

4.1. Baseline Regression

We used the line regression method to assess the impact of informal learning on pastoralists' operating income, summarizing the benchmark regression findings in Table 4. Regression 1 only adds a term for the length of informal learning. The results show that the length of the informal learning coefficient is positive, but it does not pass the significance level test. This shows that only one term of the length of informal learning is included in the model and cannot reflect the real causal relationship between the length of informal learning and herders' operating income. In regression 2, the quadratic term of the length of informal learning is added. The primary and secondary terms of the length of informal

learning are significant at the 1% confidence level, the overall goodness of fit R^2 of the model and the F statistics for testing the significance level of the model are improved, and the rationality of the model construction is further verified.

Table 4. Benchmark regression results.

Variable	Herdsman Operating Income					
	(1)		(2)		(3)	
	OLS		OLS		2SLS	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
LT	0.0718	0.0483	0.3369 ***	0.0980	0.4938 ***	0.0889
LT ²			−0.0566 ***	0.0182	−0.0774 ***	0.0129
Age	−0.0054	0.0052	−0.0051	0.0052	−0.0047	0.0050
Sex	−0.2562 *	0.1363	−0.2500 *	0.1350	−0.2559 **	0.1199
Mar	0.1060	0.2343	0.1509	0.2325	0.1618	0.1899
Edu	0.0326 **	0.0148	0.0338 **	0.0147	0.0334 **	0.0139
VC	0.1631	0.1882	0.1913	0.1865	0.1884	0.1363
Train	0.0529 **	0.0224	0.0460 **	0.0223	0.0429 **	0.0177
LF	0.0931	0.0589	0.0855	0.0584	0.0855	0.0683
Area	0.0003 ***	0.0001	0.0003 ***	0.0001	0.0003 ***	0.0001
Hge	0.2554 ***	0.0552	0.2389 ***	0.0549	0.2376 ***	0.0612
Dis2	0.0035 ***	0.0011	0.0034 ***	0.0011	0.0033 ***	0.0010
Constant	8.8427 ***	0.6487	8.8016 ***	0.6424	8.6860 ***	0.6307
LT	0.0718	0.0483	0.3369 ***	0.0980	0.4938 ***	0.0889
Observations	439		439		439	
F	9.35		9.55			
DWH test value					11.3648 ***	
R-squared	0.1942		0.2119		0.2067	

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively.

To deal with the possible endogenous problems in the model, this paper selected the distance from the nearest signal tower as the instrumental variable for the 2SLS test. The test results of the endogeneity of the variables show that (regression 3) the length of the informal learning and its square term are significant at the 1% level, indicating that there is indeed an endogeneity problem in the baseline regression model. From the results of the first stage test, instrumental variables have a significant impact on the duration of informal learning. The F statistic of the joint significance of instrumental variable coefficients is far more than 10, indicating that there is no weak instrumental variable problem.

According to the benchmark regression results, the length of informal learning and its square have significant positive and negative effects on the operating income of herdsman and are significant at the 1% level. Figure 1 shows that the impact of the length of informal learning on the operating income of herdsman presents an “inverted U-shaped”. There is a balance point in the length of informal learning, which maximizes the effect of informal learning on the increase in the operating income of herdsman. However, because the “inverted U-shaped” relationship belongs to a special curve relationship, to further ensure the reliability of the above “inverted U-shaped” relationship results, this paper used the “utest” command to test the regression 5 [54]. The results in Table 5 show that the overall t value passes the test at the significance level of 1%. The slope of the model is set to have both positive and negative values, and the extreme point position falls within the sample interval. This shows that the “inverted U-shaped” relationship is established, and Hypothesis 1 is verified.

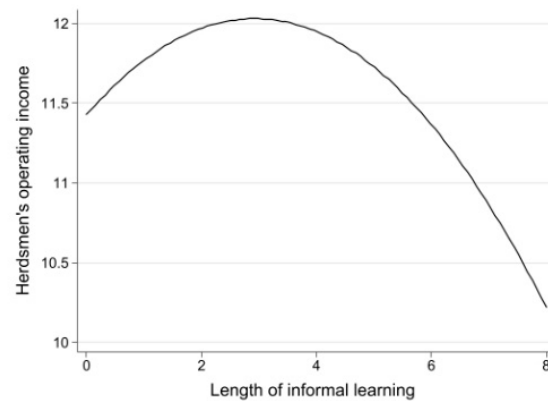


Figure 1. The “inverted U-shaped” relationship between the length of informal learning and herdsmen’s operating income.

Table 5. “Inverted U-shaped” significance test results.

Variable	Lower Bound	Upper Bound
Interval	0	8
Slope	0.3369 *** (3.4394)	−0.5683 *** (−2.6822)
Extreme point	2.9776	

Note: *t* value in parentheses. *** indicates significance at the 1% statistical level.

By comparing regression 2 and regression 3, the coefficient value of the length of informal learning in the regression results of 2SLS is much larger than that of the OLS regression results, indicating that after overcoming the endogenous problem, the positive effect of informal learning on the operating income of herdsmen is robust. Generally speaking, the balance point of informal learning duration is approximately the coefficient of the first term of informal learning duration divided by twice the square term coefficient and then expressed as a negative value. It is estimated that the inflection point is 2.9776. When the informal learning time of herdsmen is 2.9776 h, the income increase effect can be maximized.

When the length of informal learning is less than 2.9776 h, its impact on the increase in herdsmen’s operating income is in the increasing stage of the “inverted U-shaped” curve. Herdsmen can learn more information related to animal husbandry production through informal learning, which is more helpful to improve their breeding efficiency and promote the increase in herdsmen’s operating income. When informal learning time is longer than 2.9776 h, its impact on the increase in operating income of herdsmen is in the decreasing stage of the “inverted U-shaped” curve. At this stage, the short-video personalized recommendation system begins to push homogeneous production information to herdsmen. The breadth and depth of the informal learning content of herdsmen are difficult to guarantee, the negative effect plays a leading role, and the learning transformation efficiency is decreasing.

In terms of control variables, the sexuality of the household head has a significant impact on the operating income of herdsmen, which passed the 5% significance level test. However, compared with households headed by men, households headed by women have a more significant impact on the operating income of herdsmen. The production technology training passed the significance test at the level of 1%, indicating that receiving production technology training will help herdsmen increase their operating income. Among the family characteristics, the scale of grassland operation and the expenditure of human gifts passed the significance test at the level of 1% and the regression coefficients were positive, indicating that the higher the abundance of family resource endowments and the richer the social interaction, the higher the operating income of herdsmen. The distance

between the residence and the local government also passed the 1% significance level test. Generally speaking, economic activities will be affected by specific spatial structures [59]. As the regulatory body of grass–livestock balance, the closer the distance between the herdsmen’s residence and the location of the flag government, the higher the intensity and frequency of government supervision [60]. Operating income will also be affected by the differences in the external regulatory environment of the government and show differentiated characteristics.

4.2. Robustness Test

4.2.1. Winsorizing

In order to avoid the influence of extreme values on the regression results, this paper refers to the research of Meng et al. (2023) [61] and conducted a 1% tail reduction on continuous variables such as herdsmen’s operating income, informal learning time and its square term, and the frequency of production technology training. Table 6 presents the regression results; regardless of whether the control variables are added or not, the impact of informal learning duration on the operating income of herdsmen still presents an “inverted U-shaped”. The direction and significance of each variable coefficient have not changed significantly, and the winsorizing has passed the robustness test.

Table 6. Winsorizing results.

Variable	Herdsmen’s Operating Income			
	(4)		(5)	
	OLS		OLS	
	Coefficient	Std. Err.	Coefficient	Std. Err.
LT	0.4783 ***	0.1377	0.3042 **	0.1204
LT ²	−0.1036 ***	0.0352	−0.0590 *	0.0311
Age			−0.0011	0.0046
Sex			−0.1657	0.1203
Mar			0.0948	0.2067
Edu			0.0256 *	0.0132
VC			0.1752	0.1649
Train			0.0789 **	0.0332
LF			0.1025 **	0.0518
Area			0.0013 ***	0.0002
Hge			0.1971 ***	0.0493
Dis2			0.0017	0.0010
Constant	11.4276 ***	0.0925	8.7987 ***	(0.5687)
Observations	439		439	
R ²	0.0279		0.3012	

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively.

4.2.2. Quantile Regression

In view of the fact that OLS regression can only reflect the impact of various factors on the operating income of herdsmen, quantile regression is not easily affected by abnormal values, heteroscedasticity, and skewed distribution of explanatory variables. It can also examine the impact of informal learning duration on the operating income of herdsmen at different quantiles. Therefore, this paper uses the quantile regression method for the robustness test. Quantile regression model setting:

$$Q_T(\ln OT|LT) = \alpha_T + \beta_T LT_i + \gamma_T LT_i^2 + \delta_T X_i + \varepsilon_T \quad (2)$$

In the formula: $Q_T(\ln OT|LT)$ represents the operating income of herdsmen in the T quantile; LT_i , LT_i^2 is the informal learning duration of herdsman “i” and its square term; X_i represents the control variables such as householder characteristics and family

characteristics; ε_T represents the random disturbance term; and β_T , γ_T , δ_T denotes the parameter to be estimated.

According to the results in Table 7, under the 20%, 40%, 60%, and 80% quantiles, the length of informal learning has an “inverted U-shaped” impact on the operating income of herdsmen. However, its influence coefficient gradually decreases. This shows that the length of informal learning has the strongest impact on pastoralists with low operating income distribution.

Table 7. Quantile regression results.

Variable	Herdsmen's Operating Income				
	(6)	(7)	(8)	(9)	(10)
	Quantile 0.2	Quantile 0.4	Quantile 0.6	Quantile 0.8	Quantile 0.9
LT	0.5474 *** (0.1562)	0.2910 ** (0.1137)	0.2028 ** (0.0979)	0.1777 ** (0.0774)	0.0992 (0.0922)
LT ²	−0.0759 *** (0.0291)	−0.0520 ** (0.0212)	−0.0415 ** (0.0182)	−0.0445 *** (0.0144)	−0.0341 ** (0.0172)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	7.5516 *** (1.0245)	7.9585 *** (0.7458)	9.3311 *** (0.6421)	10.3679 *** (0.5072)	10.9755 *** (0.6048)
Observations	439	439	439	439	439

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively. Standard errors are in parentheses. The value outside the parentheses is the estimated coefficient of the variable.

4.2.3. Substitution Variable

This paper further tested the robustness by replacing the explained variables, adjusting the control variables, and deleting some samples.

Firstly, this paper used the proportion of annual animal husbandry operating income to total income to replace the annual animal husbandry operating income in the benchmark regression. Regression (11) of Table 8 indicates that the first and second terms of informal learning duration are significant, and the first-term coefficient is positive, and the second-term coefficient is negative, indicating that there is an “inverted U-shaped” relationship between informal learning duration and the proportion of annual animal husbandry operating income to total income. The above conclusions are consistent with the benchmark regression conclusions.

Secondly, this paper only considered the influence of the education level of the head of the household in the benchmark regression, and the education level of other members of the herdsman family engaged in animal husbandry production will also affect the operating income. Therefore, this paper replaced the education level of the head of the household with the highest education level of the family labor force. Regression (12) of Table 8 indicates that the after controlling the highest education level of the family labor force, the model estimation results are consistent with the benchmark regression results. The proportion of informal learning time also has an “inverted U-shaped” relationship of “first promotion, then inhibition” with the operating income of herdsmen.

Finally, in the context of increasing aging, if the herdsmen are older, their ability to operate network application software and screen network information is relatively weak, which will affect their initiative and the learning effect of informal learning. So, the data of older herdsmen are eliminated. According to the actual situation of the investigation in the pastoral area, it is found that more heads of households over 60 years old are still engaged in animal husbandry production. In this paper, the age of herdsmen is appropriately extended by 5 years, and the data of herdsmen over 65 years old are eliminated [62]. Regression (13) of Table 8 indicates that after processing the data, informal learning still has a significant positive impact on the operating income of herdsmen, and there is also an “inverted U-shaped” relationship between the length of informal learning and the operating income of herdsmen.

Table 8. Robustness test results.

	Proportion of Herdsmen's Operating Income		Herdsmen's Operating Income			
	(11)		(12)		(13)	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
LT	0.0718	0.0483	0.3369 ***	0.0980	0.4938 ***	0.0889
LT ²			−0.0566 ***	0.0182	−0.0774 ***	0.0129
Age	−0.0054	0.0052	−0.0051	0.0052	−0.0047	0.0050
Sex	−0.2562 *	0.1363	−0.2500 *	0.1350	−0.2559 **	0.1199
Mar	0.1060	0.2343	0.1509	0.2325	0.1618	0.1899
Edu	0.0326 **	0.0148	0.0338 **	0.0147	0.0334 **	0.0139
VC	0.1631	0.1882	0.1913	0.1865	0.1884	0.1363
Train	0.0529 **	0.0224	0.0460 **	0.0223	0.0429 **	0.0177
LF	0.0931	0.0589	0.0855	0.0584	0.0855	0.0683
Area	0.0003 ***	0.0001	0.0003 ***	0.0001	0.0003 ***	0.0001
Hge	0.2554 ***	0.0552	0.2389 ***	0.0549	0.2376 ***	0.0612
Dis2	0.0035 ***	0.0011	0.0034 ***	0.0011	0.0033 ***	0.0010
Constant	8.8427 ***	0.6487	8.8016 ***	0.6424	8.6860 ***	0.6307
LT	0.0718	0.0483	0.3369 ***	0.0980	0.4938 ***	0.0889
Observations		439		439		439
F		9.35		9.55		
DWH test value					11.3648 ***	
R-squared		0.1942		0.2119		0.2067

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively.

4.3. Heterogeneity Analysis

Affected by the difference in human capital, herdsmen with different human capital have differing acceptance of informal learning, and the quality of learning and the efficiency of learning transformation are also different, which will lead to differences in the impact of informal learning on the operating income of herdsmen. This paper selected the education years of the head of household as the grouping basis. According to the data of the seventh national census of the Inner Mongolia Autonomous Region, the average years of education of the permanent population aged 15 and above in the sample area is 9.75 years. Therefore, this paper divided the herdsmen with more than or equal to 10 years of education into the high human capital group, and the herdsmen with less than 10 years of education into the low human capital group.

Table 9 presents the regression results, from the perspective of the difference in years of education, the length of informal learning has a positive impact on the operating income of herdsmen in the low human capital group at a significant level of 1%. There is still an “inverted U-shaped” relationship between the length of informal learning and the operating income, and the “charcoal in the snow” effect is significant. However, the impact on herdsmen in the high human capital group is not significant, and the effect of “icing on the cake” is not supported by the data.

The reason may be that high human capital herders have high cognitive ability. Even without informal learning, they can obtain animal husbandry production information through other channels, grasp the essence of animal husbandry policy, and establish modern animal husbandry production and management concepts, to optimize production structure and improve production output, quality, and sales. However, herders with low human capital may be limited by traditional ideas and long-term farming experience, and their willingness to adopt new technologies is low. At this time, informal learning can help them digest and absorb modern animal husbandry policies and production information, adopt new production technologies, break the constraints of traditional agricultural and animal husbandry production technologies and experience, and increase the rate of return on the adoption of animal husbandry production technologies, thus promoting a steady increase in operating income [63].

Table 9. Test results of human capital leading to heterogeneity.

Variable	High Human Capital		Low Human Capital	
	(14)		(15)	
	Coefficient	Std. Err.	Coefficient	Std. Err.
LT	0.1674	0.2127	0.3890 ***	0.1457
LT ²	−0.0307	0.0294	−0.0720 *	0.0367
Control variables	Yes	Yes	Yes	Yes
Constant	6.1581 ***	1.5887	9.3782 ***	0.7637
Observations	104		335	
Extreme point			2.7030	
R ²	0.3291		0.1849	

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% statistical levels, respectively.

In addition, compared with the extreme point of the overall informal learning time, the extreme point of the informal learning time of the low human capital group is lower ($2.7030 < 2.9776$). This result shows that the knowledge reserve of low human capital herdsmen is relatively insufficient. To improve the current situation of lagging technical concepts, a shortage of knowledge, and insufficient application ability, they can acquire more knowledge in a short period of informal learning, to improve their ability to obtain market information and production and operation efficiency, thus increasing the operating income of animal husbandry.

5. Conclusions and Implications

Based on the micro-survey data, this paper explored the impact and mechanism of informal learning on the operating income of herdsmen. The results show that, firstly, the impact of informal learning on the operating income of herdsmen is “inverted U-shaped”. There is an extreme point of informal learning time of 2.9776 h, which maximizes the effect of informal learning on the increase in the operating income of herdsmen. After being tested by winsorizing, quantile regression, and substitution variables, the conclusion is still robust. Secondly, from the difference in years of education, the length of informal learning has a positive impact on the operating income of herdsmen in the low human capital group at a significant level of 1%, and there is still an “inverted U-shaped” relationship between the length of informal learning and the operating income, and the effect of “sending charcoal in the snow” is significant. It shows that low human capital herdsmen can master more technical information of animal husbandry production through informal learning, to improve their production and operation ability and better promote the increase in operating income. However, the impact on the high human capital group is not significant, and the effect of “icing on the cake” has not been supported by the data.

Based on the above conclusions, this paper believes that improving the operating income of herdsmen should focus on the following three points. Firstly, increase the support for the construction of Internet infrastructure in pastoral areas and improve the level of broadband penetration in pastoral areas. Expanding the coverage of the Internet in pastoral areas is an important measure to improve the informal learning of herdsmen. While improving the Internet penetration rate, we will enhance the access capacity and signal stability of the home network, improve the information service network in pastoral areas, solve the “last mile” problem of information dissemination, and meet the needs of herdsmen for informal learning. Secondly, the township (Sumu) government should closely focus on the problems encountered in the production of herdsmen, find out and count the needs of herdsmen for breeding skills and management. Platform resources such as the official account of a self-media short video should be used to find the target herdsmen for a precise push to overcome information homogenization. Finally, the herdsmen quality improvement project should be implemented. On the one hand, government departments should promote the action of improving the quality of herdsmen, drive herdsmen to change their ideas and production methods and improve herdsmen’s objective and rational

understanding of science and technology. On the other hand, herdsmen themselves should also consciously improve their comprehensive abilities such as ideological and political knowledge, practical skills, policies and regulations, and cultural literacy. By improving the comprehensive quality and personal learning ability of herdsmen, they can promote herdsmen to understand more new technologies of animal husbandry production and management and improve their operating income level.

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