Wool Production’s Quality Control Behavior: An Empirical Study of the Status and Determinants

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Abstract. Based on the survey data of sheep farmers in 4 provinces in the west of China, using the binary logistic regression model, we analyzed the adoption of key technologies for wool quality control, such as "sheep clothing" technology, mechanical shearing technology, and wool grading technology. Statistics suggest that 54% of the farmers used the "sheep clothing" technology, 34% of the farmers used the mechanical shearing technology, while 56% of the farmers used the wool grading technology. The number of training and the expected sales price of wool significantly promoted the adoption of these three key technologies by farmers. However, risk preference negatively affects the adoption of three technologies. The total family income, farming scale, level of wool yield and breeding loans are positive to "sheep clothing" technology and mechanical shearing technology. The level of education and farming experience positively affects the "sheep clothing" technology, while culture of regional environmental negative to it.

1. Introduction
With the rapid development of the national economy and the rising level of people’s life, the high-grade wool manufactured goods are going into thousands of households, becoming a mass consumer product. Therefore, the demand for high quality wool and textile industry will also rise and the development of the wool industry in China is facing great opportunities. However, the growth of this demand has not brought about the optimization adjustment of domestic wool structure. In 2015, the wool yield of Chinese sheep increased by 135 thousand tons compared with 2000, of which the fine wool only increased by 17 thousand and 600 tons. The proportion of fine wool to sheep wool decreased from 40.13% in 2000 to 31.57% in 2015. The factors of low staple length rate, uneven levels, wool and sales of domestic wool lead to the poor quality. It is difficult to adapt to the needs of domestic wool processing textile industry, supply and demand gap to be filled with high quality imported wool. Since twenty-first century, China has imported a substantial increase in the number of wool, especially since the number of Australian imports from 102 thousand tons in 1999 to 185.9 thousand tons in 2000, and thereafter the annual import volume was maintained at 180 thousand tons in the next level. The increase of imported wool will inevitably inhibit the production of domestic wool, and then impact on the development of China's wool industry. Therefore, improving the quality of domestic wool has become an urgent problem to be solved in the further development of wool industry in China.

The technology adoption behaviour of herdsman is affected by many factors, mainly including the individual characteristics factors, the family household characteristics factors, the breeding characteristics factors, society, economy and environment factors. The herdsman of old age and low educational level of the new things on the ability of recognition and learning and acceptance ability is worse; the total family income, farming income proportion and the scale of farming to the breeding
technology adoption have a positive role in promoting; farming cooperatives and related technical training will have significant influence on herdsmen’s technology adoption.

The existing research on quality control of farm household behaviour is mainly around the types of edible agricultural products, such as grain, vegetables, meat and milk, Chinese herbal medicine and tea. According to the research of farm household behaviour wool quality control is still rare. The research relates to the research of its influence is especially very few. The further development of China’s wool industry depends on the improvement of wool quality, while the improvement of wool quality depends on the wool quality control behaviour of sheep farmers. Therefore, this paper uses survey data for empirical analysis, to the behaviour of key technology to control the quality of wool as explanatory variables, to farmers individual characteristics, family characteristics, culture characteristics, social, economic and environmental characteristics and other factors as independent variables. We made use of the binary Logistic regression analysis model to analyse the influence factors of farmers wool quality control behaviour in the paper, and put forward the conclusions and policy recommendations to break the bottleneck of the quality control of decision-making of the herdsman, further enhance China's wool quality to guarantee the continues and healthy development of China's wool industry.

2. Materials and Research Methods

2.1 Data resources
The data of this paper comes from the field research of the project team in four sheep breeding main provinces (regions) of Inner Mongolia, Xinjiang, Gansu and Qinghai in July and August in 2016. We used the random sampling method. Two counties were randomly selected in each province (area); two villages were randomly selected in each county; ten rural households were randomly selected in each village. Through the investigation of group members and farm households on a questionnaire, a total of 160 households were investigated and 147 valid questionnaires. The effective questionnaire was 91.88%. The investigation includes: (1) farmers with quality control techniques, such as the quality control technique is adopted or not, not by reason, future adoption and related technical training times; (2) the basic social and economic characteristics of rural households, such as age, education level, risk preference, social relations, family income, population, breeding, production and sales of wool. The main survey sample households to males, the average age of nearly 46 years, primary school and junior high school education accounted for most of home village cadres accounted for 16.41%. The breeding period is generally longer, of which 25-35 years of farming households accounted for 39.37%. The breeding scale mainly concentrated in 100-200, accounting for 62.94% and the proportion of aquaculture income accounted for 66.70%.

2.2 Research Methods
For the key technology of wool quality control, three models are set up in this paper. The three models are herdsmen wear “sheep clothing”, mechanical shearing and the behavior decision model of influencing factors of the wool grading sorting. According to the characteristics of dependent variables -- two classification variables, this paper uses Binary Logistic Regression Model to analyse it. The following econometric models of Logit are established:

\[ P(y = 1 \mid x) = F(x, \beta) = \Lambda(x' \beta) = \frac{\exp(x' \beta)}{1 + \exp(x' \beta)} \]

Record \( p = P(y = 1 \mid x) \), thus, we have: \( 1 - p = P(y = 0 \mid x) \).
Therefore,

\[ \ln \left( \frac{p}{1 - p} \right) = x' \beta. \]
The $F(x, \beta)$ is the cumulative distribution function of Logistic distribution. $Y$ is the dependent variable, representing whether the farmers adopt the wool quality control technology; $P(Y = 1 | x)$ represents the probability of the herdsman adopts the wool quality control technology; $x$ is the independent vectors, representing many factors affecting the agricultural households to adopt the wool quality control technology; $\beta$ is the parameter to be estimated to amount.

2.3 Variables Selection
We select the age of the household head, education level, risk preference, family income, sheep farming income, farming experience, farming scale, wool yield level and participate in farming cooperative organizations, participate in technical training, farming loans, wool expected domain environment culture area sales price, as independent variables. We take the situation of wearing sheep clothing technology, mechanical technology, wool grading technology as the dependent variable. The variables are shown in Table 1. We use the Logistic model to analyse the factors influencing the herdsman whether to adopt the wool quality control technology.

| Table 1. Variable definition |
|-----------------------------|
| Category | Variable | Definition | Mean | Standard deviation |
| Dependent variable | Technology of wearing wool | No=0, yes=1 | 0.54 | 0.50 |
| | Mechanical shearing technology | No=0, yes=1 | 0.34 | 0.48 |
| | Wool grading technology | No=0, yes=1 | 0.56 | 0.50 |
| | Age | Actual age of the household head | 45.90 | 9.06 |
| Personal features | Educational level | The educational level of the household head: uneducated person=1, primary school=2, junior school=3, senior school/vocational school=4, college/university=5 | 2.98 | 1.00 |
| | Risk preference | Risk preference of the household head: unwilling to take risks=1, ordinary risk preference=2, willing to take risks=3. | 1.82 | 0.84 |
| Family features | Family income | Expected total family income (ten thousand) | 15.97 | 15.39 |
| | Income proportion of breeding sheep | Expected income proportion of breeding sheep to total family income (10%) | 65.69 | 25.19 |
| | Breeding experience | Accumulated time in sheep industry (years) | 28.08 | 12.66 |
| Breeding features | Breeding scale | Actual population of basal ewe of the herdsman’s household in the investigation period | 194.39 | 199.01 |
| | Per unit yield | Actual yield level of a basal ewe (kilos) | 4.15 | 0.81 |
| | Cooperative member | Whether the cooperative member or not. No=0, yes=1. | 0.46 | 0.50 |
| | Training times | Technology training times in every year | 0.75 | 1.18 |
| | Breeding loan | Whether have breeding loan in the last three years. No=0, yes=1. | 0.90 | 0.30 |
| Social, economic and environment feature | Expected wool price | Expected wool price (Yuan/kilo) | 26.91 | 4.28 |
| | Culture regional | Whether there is much shrub vegetation. No=0, yes=1. | 0.27 | 1.59 |
3. Results and Analysis

The descriptive statistics of the herdsman’s wool quality control behaviour shows that the adoption rates of the three quality control technologies of the “sheep clothing”, mechanical shearing and wool grading are generally low and less than 60%. The mechanical shearing technology adoption rate is only 34%. This is the key to the quality of wool, such as low net wool ratio, uneven length of wool tuft and mixed grade sales. The following three factors will be used to analyze the influencing factors of behavior adoption. The model integrity test showed that the Chi-Square test values of the three models were significant at the 1% level, indicating that the model fitted well.

3.1 Analysis of Influencing Factors of the Adoption Behaviour of “Sheep Clothing”

The regression model of "sheep clothing" showed that the probability of adopting "sheep clothing" technology for herdsmen increased by 98.43%. The type of risk appetite of farm households by wearing "sheep clothing" technology probability than the risk averse farmers decreased 3.02 times. In the family characteristic variables, the household income increased by ten thousand yuan, and the probability of adopting "sheep clothing" technology for farmers and herdsmen will increase by 0.35%. Breeding characteristic variables, breeding experience each year, or every increase a sheep herds, or sheep wool yield per kg, the wear "sheep clothing" by the probability of significantly increased 11.11%, 0.26% and 143.94%. The economic and social environment variables, and farmers to accept "sheep wear clothes" technical training number of each one, the probability of using the technology was increased 5.95 times. For the past three years breeding loan of farmers using the probability of wearing "sheep clothing" technology is not for nearly 10 times the farming herdsman's loan. The expected price growth one yuan per kilogram of wool, farmers use probability to wear "sheep clothing" technology significantly improved by 27.58%. The probability of Adoption Behaviour of Wearing “Sheep Clothing” of the herdsman whose breeding areas located in shrubs vegetation significantly decreased by 11.24 times than that of the herdsman who has no such environment.

3.2 Analysis of Influencing Factors of the Adoption Behaviour of Mechanical Shearing Technology

The results of the mechanical shearing model regression showed that in the personal characteristics variables, risk preference of herdsmen by mechanical shearing technology decreased 2.16 times than the probability of the risk averse households. Household characteristics variables, total household income increased by ten thousand yuan each, the probability of farmers and herdsmen by mechanical shearing technology will increase 0.80%. Breeding characteristic variables, each increase of one sheep herds, or sheep wool yield per kg, farmers will increase 0.39% and 164.63% respectively. The probability of using mechanical shearing technology. The economic and social environment variables, and rural households receiving mechanical shearing technical training number of each one, the probability of using the technology significantly increased 2.66 times; the probability of nearly three years of loan for farming herdsmen by mechanical shearing technology is not nearly 4 times the agricultural farming loans households per kilogram. When the he wool price is expected to increase a yuan, the probability of the herdsman households adopting mechanical shearing technology will significantly increase by 77.72%.

3.3 Analysis of Influencing Factors of the Adoption Behaviour of Wool Grading Technology

Wool grading regression results show that in the personal characteristics variables, the probability of the risk preference herdsmen households using wool grading technology decreased 2.25 times than that of the risk averse households. The economic and social environment variables, and farmers accept wool grading finishing technology training times each time, the probability of using the technology significantly increased 2.94 times; If every kilogram of wool prices grows by a yuan, the probability of the wool grading technology adoption of the herdsman households will significantly improve by 127.63%.
Table 2 Logistic model of quality control technology using behaviour

| Variable                      | "Sheep clothing" technology | Mechanical Shearing Technology | Wool Grading Technology |
|-------------------------------|-----------------------------|--------------------------------|-------------------------|
| Age                           | 0.0089                      | -0.0287                        | -0.0172                 |
| Educational level             | 1.9843*                     | 0.4984                         | 0.5659                  |
| Risk preference               | -3.0223***                  | -2.1601***                     | -2.2535**               |
| Family income                 | 1.0035*                     | 1.0080**                       | 0.0000                  |
| Income proportion of breeding sheep | -0.0165                  | 0.0047                         | 0.0206                  |
| Breeding experience           | 1.1111**                    | -0.0243                        | -0.0114                 |
| Breeding scale                | 1.0026**                    | 1.0039***                      | 0.0015                  |
| Per unit yield                | 2.4394*                     | 2.6463**                       | -0.1638                 |
| Cooperative member           | -2.3297                     | 0.3017                         | -0.0108                 |
| Training times                | 6.9458***                   | 2.6604***                      | 2.9367**                |
| Breeding loan                 | 9.9202**                    | 3.8568**                       | -1.2717                 |
| Expected wool price           | 1.2758*                     | 1.7772***                      | 2.2763***               |
| Culture regional environment  | -11.2547***                 | -                               | -                       |
| Constant                      | -16.502                     | -15.8379***                    | -32.2968***             |
| Chi-square test value         | 0.7738***                   | 0.6477***                      | 0.7966***               |

Note: * , ** and *** represent the significance levels of the estimated values are separately 10%, 5% and 1%.

4. Discussion

The empirical results show that the herdsman’s received training and the expected sales price of wool have significant positive effect on three key technologies to control the quality of wool by the herdsman. The reason for the not adoption the three key technologies mainly lies in the lack of technical understanding or difficult to master the technologies without the training that can solve the two problems of farmers, and promote farmers the wool quality control technology is adopted, and the "high quality" is the pricing principle of wool trading market, farmers expected to gain a high level of wool sales price, to provide a high quality wool, and therefore will actively adopt quality control technology of wool. Risk appetite is negatively affected by the three technologies, this is because the farmers with quality control behaviour is the cost of the period, and the income is in the future, with uncertainty, risk averse farmers to ensure the future earnings, tend to be more in the current implementation of strict quality control behaviour of wool. The total family income, farming scale, level of wool yield and breeding loans are positive by wearing "coat" and mechanical shearing of the two technology, which is mainly related with the characteristics of the two technology itself, because these two technologies in the actual needs of the capital investment, and family income and farm loans it reflects the budget constraints facing farmers production decision, relax the restriction will increase in sheep clothing and mechanical shearing technology adoption rate, in addition, it is also because of these two technologies will need to invest a certain cost in use, and the higher the yield of wool, the wool in the unit weight allocation the cost is small, so the wool production reaches a certain level, farmers of the two technologies will increase the probability. The level of education and farming experience have significant positive effects in sheep clothing technology of farm household use, this is because in "sheep clothing" after the sheep hunger degree and epidemic disease situation is not easy to identify, but with the farmers educational level and enhance the growth of their breeding experience, technical mastery and the degree of processing capacity will increase, the probability of wear "sheep clothing" techniques are used increases; breeding area environment has a significant negative impact on the wear of sheep clothing technology. At present, it is still difficult to eliminate the damage caused by shrub to the sheep clothing. The ratio of sheep's wool to sheep's total income is not high. If it is needed to frequently increase the cost investment, the herdsmen enthusiasm for “sheep clothing” will inevitably be suppressed.
From the four aspects of personal characteristics, family characteristics, culture characteristics, social, economic and environmental characteristics, this paper made an empirical study on the adoption behaviour of the “sheep clothing” technology, mechanical shearing technology and wool grading technology of the herdsmen. The shortcomings are as follows: first, due to limited conditions, the survey data is cross sectional data, which may not reflect the changes in the quality control technology adopted by farmers and herdsmen. The second is the study area failed to cover the whole western sheep breeding area. Therefore, in future studies, we can expand the scope of the study, and increase the panel data to analyse the herdsman’s technology adoption dynamically rather than statically.

5. Constructions
(1) There are 54% of the herdsman households adopting "sheep clothing" technology, only 34% of the herdsmen households adopting mechanical shearing technology. There are 56% of the herdsman households adopting the wool grading technology.

(2) The level of education, family income, breeding experience, breeding scale, yield level, training times, breeding loans and the expected price have significant and positive impact on the adoption behavior of the “wool clothing” technology. However, the risk preference and culture regional environment have negative influence on the behavior of adopting the technology for the herdsmen households.

(3) The total family income, farming scale, yield level, training times, farming loans and wool expected price have significant and positive influence the behavior of herdsman’s mechanical shearing technology, and risk appetite negatively influence the behavior of using the technology.

(4) The training times and the expected price has significant positive impact on the adoption behavior of the wool grading technology for the herdsman households, and risk preference negatively influence the behavior of using the technology.

According to the above conclusions, this paper puts forward the following suggestions: first, improve the technical training mechanism and train high-quality herdsmen team. Through multiple channels and ways of the technical training, such as the home instruction, expert lectures, technology promotion spot, we send the information and technology timely to the hands of herdsmen. Second, standardize the wool trading market and promote wool trading quality, price and healthy development. Third, continue to carry out large-scale farming and breeding to improve the average wool yield level. Fine variety is the foundation of the wool quality guarantee, and large-scale breeding is beneficial to the popularization of wool quality control technology. Fourth, improve the rural financial system and increase financial support. We should solve the current problems of high interest, limited amount and cumbersome procedures of the rural finance to lower the household financial lending threshold and broaden the channels of financial credit. Fifth, improve the culture regional environment with perseverance. Start the ecological protection and construction projects of good grass seed, grassland disaster prevention and mitigation, grassland nature reserve construction, grassland development and utilization, pastoral area water conservancy as soon as possible to create a favorable environment for the development of sheep breeding industry.

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References
[1] Green G, Sunding D, Zilberman D, et al. Explaining Irrigation Technology Choices: A Microparameter Approach[J]. American Journal of Agricultural Economics, 1996, 78(4): 1064-1072.
[2] Feder G. Adoption of Interrelated Agricultural Innovations: Complementarity and the Impacts of
Risk, Scale, and Credit[J]. American Journal of Agricultural Economics, 1982, 64(1): 94-101.

[3] Smale M, Heisey P W, Kaunda Z H W, et al. Chimanga cha makolo, hybrids, and composites: An analysis of farmers' adoption of maize technology in Malawi, 1989-91[J]. Cimmyt Economics Working Paper, 1992.

[4] Cai Rong, Han Hongyun. Analyzing the Determinates of Farmers Choice of Participate in Cooperatives— Based on Apple Growers from Shandong Province [J]. China Rural Survey, 2012(5): 32-40.

[5] Kong Xiangzhi, Fang Songhai, Pang Xiaopeng, Ma Jiujie. Analysis of the Effect of Household Endowments on the Agricultural Technology Adoption Decision in West China [J]. Economic Research Journal, 2004(12):85-95+122.

[6] Huang Wu, Huang Hongwei, Zhu Wenjia. An Empirical Study on Farmer’s Utilization of Crop Straw [J]. China Rural Survey, 2012(4): 37-43.

[7] Niu Yali. The Analysis on Farmers’ Quality and Safety Control Behavior and Its Influencing Factors in "Farmer-Supermarket Direct Purchase" Based on the Survey from 484 Farmers in Liaoning Province [J]. Journal of Sichuan Agricultural University, 2014, 32(2): 236-241.

[8] Cottle D, Gaden C A, Hoad J, et al. The effects of pasture inputs and intensive rotational grazing on superfine wool production, quality and income[J]. Animal Production Science, 2013, 53(8): 750-764.

[9] Easdale M H, Sacchero D, Vigna M, et al. Assessing the magnitude of impact of volcanic ash deposits on Merino wool production and fibre traits in the context of a drought in North-west Patagonia, Argentina[J]. The Rangeland Journal, 2014, 36(2): 143-149.

[10] Amarilho-Silveira F, Vicente S V, Lemes J S, et al. Relationship between levels of blood metabolites and wool quality[J]. Archivos de Zootecnia, 2017, 66(253): 137-140.

[11] Väntsi O, Kärki T. Mineral wool waste in Europe: a review of mineral wool waste quantity, quality, and current recycling methods[J]. Journal of Material Cycles and Waste Management, 2014, 16(1): 62-72.

[12] Wiedemann S G, Ledgard S F, Henry B K, et al. Application of life cycle assessment to sheep production systems: investigating co-production of wool and meat using case studies from major global producers[J]. The International Journal of Life Cycle Assessment, 2015, 20(4): 463-476.

[13] Corscadden K, Stiles D, Biggs J. Scale and sustainability: An exploratory study of sheep farming and adding value to wool in Atlantic Canada[J]. Agroecology and Sustainable Food Systems, 2017: 1-21.

[14] Meale S J, Chaves A V, He M L, et al. Dose–response of supplementing marine algae (spp.) on production performance, fatty acid profiles, and wool parameters of growing lambs[J]. Journal of animal science, 2014, 92(5): 2202-2213.

[15] de la Hera G, Muñoz-Díaz I, Cifrian E, et al. Comparative Environmental Life Cycle Analysis of Stone Wool Production Using Traditional and Alternative Materials[J]. Waste and Biomass Valorization, 2017, 8(5): 1505-1520.

[16] Khan N N, Kumar N, Das A K, et al. Genetic studies on wool production traits in Rambouillet crossbred sheep in J & K State, India[J]. Indian Journal of Animal Research, 2015, 49(1).