The Impacts of Agricultural Machinery Purchase Subsidies on Mechanized Crop Residue Recycling

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Abstract Crop residue recycling can improve the quality of the cropland, and it has multiple economic and ecological benefits. However, such practice is with low adoption due to different constraints. In this paper, we use the survey data from Baoding, Hebei province, and use the probit model to explore how the agricultural machinery purchase subsidies affect the mechanized crop residue recycling. The results showed that several factors that affect farmers in adopting the practice of mechanized crop residue crop recycling. Among these factors, the cost of adopting such practice is significant. The agricultural machinery purchase subsidies can effectively reduce the cost of such practice, as well as promote mechanized crop residue recycling. The paper also proposed several actions in the future. They include increasing the subsidies on agricultural machinery purchase and increasing farmers' awareness on crop residue recycling.

Key words Agricultural machinery purchase subsidies, Mechanized crop residue recycling, Probit model, China

Crop residue recycling can improve the quality of soil and it has the significant economic interests and ecological interests. According to the *Investigation and Evaluation on the Quality Grade of Chinese Farmland*, which is issued by the Ministry of Land and Resources in 2009, the farmland in whole country get the socre 9.80 on average (the highest quality get score 1 while the lowest quality get the score 15) and this score shows that the quality of our farmland is low[1]. In China, the middle and low yield farmland accounts for 2/3 of total farmland and the organic content of farmland has only 1.8%[2]. The crop residue recycling of agricultural products can increase the organic content of soil[3]; increase the water conservancy and water contenting capability of soil[4]; and increase the land productivity. The practice is also benefit for developing low-carbon agriculture and alleviating greenhouse effect[5]. Every year, China produces 0.62 billion ton of crop residues but only 15% of them can be returned to land. 80% If the crop residue can be returned to land, the carbon balance of farmland can turn loss to profit-making[6]. At present, the crop residue is an effective way for using crop residue[7]. The benefits of recycling crop residue to farmland are larger than the berefits of producing electricity by using the crop residue and the energy produced by crop residues[8]. However, the current proportion of recycling the crop residue is low due to various factors. Mechanized crop residue recycling refers to that the rural households smash the crop residue by using machines to return to land directly and the crop residue decomposes to organic fertilizer in land[9]. Mechanized crop residue recycling has the advantages of saving time and energy, which is conducive to promoting crop residue recycling. But due to the poor university of crop residue smashing machine, rural households' purchasing wiliness will be affected. Using machine to smash crop residue costs more which restricts the promotion of mechanized crop residue recycling. In 2006, the machine used for smash crop residue was put on the namelist of machine eligible for purchase subsidy offered by the central government. Rural households who buy machine can apply the subsidies for buying agricultural machine. On the basis of the spot investigation on two villages in Baoding City of Hebei Province, the Probit model studies the impacts of agricultural machine purchase on mechanized crop residue recycling from the micro-level.

1 Data source and research method

1.1 Data source

1.1.1 General description of sample area. The paper takes two villages in Dingxing County and Gaobeidian City respeclivtly. The production volume of crop residue resources in Hebei Province ranks the third in the country. Baoding City is a granary city in central Hebei Province. By the end of 2009, the total area of farmland of the whole city was 12 515 000 hm^2. The major grains cultivated are wheat and corn (the proportion of wheat and corn is 1:1.25). Baoding City has rich crop residue resources and June and October are the harvest moths. Since 2000, the local people have begun to promote the combine harvester of wheat. In 2008, the city has realized the mechanized crop residue recycling. Before 2003, the residue of corn in the Baoding was mainly uses as living energy and stock feed. With the further construction of new village, the structure of rural living energy consumption has changed completely. The proportion of using corn residue as fuel and fodder sharply. A large amount of corn residues are abandoned or piled in the fields or torrent ditch. Burning the crop residue is widespread and it leads to the environmental pollution and resource wastes. Only a small number of the corn on residues was smashed and re-

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turned to farmland manually.

At that time, the corn residue can be used as fodder, fuel as well as wastes. After the crop residue recycling appeared in 2005, most farmers think the costs of crop residue recycling cost more (750 yuan /hm^2). Most farmers are suspicious of the new technology, so they do not have enthusiasm on applying the technology. Few rural households apply the technology because of the lack of labors. In 2009, the machine for smashing crop residue was eligible for purchase suksidies in Hebei Province and this promote the purchase of such machine. The number of the machines used for smashing crop residue in the two villages reached to 10, which leads to the prices of crop residue recycling declined. The rural households are stimulated to use mechanized crop residue recycling. With the transfer of local labors, young and strong labors are insufficient and leaded to the rise of the local wage, so the mechanized crop residue recycling is widely accepted in 2010.

1.1.2 Description of the characteristics of samples. From October, 2010 to November, 2010, the investigation team went to Baoding City of Hebei Province to get the first-hand resources. The stratified sampling and equal-distance sampling were applied. 90 household were selected from 900 rural households in the survey. The questionnaires and in-depth interview with the numbers of the households is used in the survey. 90 questionnaires in the investigation are issued and 84 valid questionnaires are returned, the returning rate is 93.3% of the total samples. In the sampling survey, the changing situation of handling crop residues and the changes of prices of mechanized crop residues and the market price of coal from 2008 to 2010 can be seen on Table 1.

Table 1 Changes in the different treatment of straw and the changes of prices from 2008 to 2010

Year	Mechanized crop residues recycling rate//%	Straw feed rate//%	Straw energy//%	Abandon at will//%	Price of mechanized crop residue recycling//yuan/hm^2	Price of coal yuan/t
2008	14.29	11.90	13.10	61.90	825	560
2009	16.67	10.71	11.90	60.71	810	551
2010	66.70	8.30	7.50	17.50	750	527

Note: The price is on the basis of the price in 2008 and calculated according to the equation of actual price = Nominal price/Index number of the very year.

Table 1 shows that the proportion of rural households mechanized crop residues recycling has come to 66% in 2010, 52% higher than that in 2008. Most of the sample rural households have four family members; the proportion of working out of each household is 33%. The rural household heads are mainly the young men. Most of the young men have accepted more than six to nine years of education and the farmland size is 0.33 hm^2 on average. With whether applying mechanized crop residues recycling, rural households mainly consider whether the mechanized crop residues can bring maximum interests rather than per capita income. Rural households, which have the income from animal husbandry, do not adopt the mechanized crop residues recycling. Among the rural households which have adopted the mechanized crop residues recycling, 29% of rural households hold the uncertain attitudes toward using mechanized crop residues recycling in the next season. When the costs of mechanized crop residues recycling reduce, the possibility of using mechanized crop residues recycling will increase. The variable definition and statistical characteristics can be seen on Table 2.

1.2 Establishment of model On the basis of the sample places and thebasis of former scholars' researches[10], the model does not consider the individual features of rural households, per capita income but the variables related to the machinery subsidies. The three factors including local market features, rural households' mechanized crop residues recycling behaviors and feature of rural households as the major factors. Supposing that the mechanized crop residues recycling of rural households are determined by family utility function and then the assumption of theoretical model is as follows:

$U = f$(Market features, rural households' mechanized crop residues recycling behaviors, features of rural households) + Random disturbance term.

Table 2 Variable definitions and statistical characteristics

Types of variables	Definitions of variables	Value of variables	Prediction trend
Dependent variables	Whether recycling the crop residues	Yes = 1; No = 0	–
Variable of market	Price of mechanized crop residues recycling yuan/hm^2		–
	Price of coal//yuan/t		–
Variable of rural households' behaviors on crop Residue recycling	Household masters' recognition on crop Residues recycling	Value 1 – 5	+
	Whether used the crop residues recycling last year	Yes = 1, no = 0	+
Variables of household variables	Total number of family members//people		?
	Proportion of workingout//%		+
	Whether has the income of animal husbandry	Yes = 1; no = 0	+

Note: " + " means that independent variable has positive correlation with dependent variable; " – " means negative correlation; " ? " refers to uncertainty. The price of mechanized crop residues recycling and coal is calculated through unchanged price adjusted by price index.

Taking whether adopting the technology of crop residues recycling of rural households as the explained variable(yes = 1, no = 0) and selecting the bivariate response model – Probit model to conduct analysis[10].

The Probit model is often applied in the research of behaviors. Probit model can be seen as follows:

$$\text{Prob}(Y=1\mid x)=G(x\beta)=\Delta\hat{P}(y=1\mid x)\approx[g(\hat{\beta}_0+x\hat{\beta})\hat{\beta}_j]\Delta x_j=\Delta\hat{P}(y=1\mid x)\approx[g(\hat{\beta}_0+x\hat{\beta})\hat{\beta}_j]\Delta x_j$$

2 Results and analysis

2.1 Regression results of Probit model By using the Stata10.0 statistical software, the Probit regression handling is conducted on seven explained variables that affect rural households' behaviors on crop residues recycling. The regression results can be seem on Table 3. Through optimizing and adjusting the Probit model, the last step of regression results show that the Chi-Square value is 88.03, the test significance of maximum likelihood estimation is 0.00, which indicates that the overall fitting effects of the model is good.

It can be seen from Table 3 that whether adopting crop residues recycling at the previous years, the proportion of working out, rural households' recognition on crop residues recycling have positive effects on rural households' behaviors on crop residues recycling. The price of local mechanized crop residues, price of coal, total number of family members, whether there are crop-feeding stocks have significant negative effects on the rural households' behavior of adopting crop residues recycling.

Table 3 Probit regression results

Variables	Regression coefficient	Standard error	*z* statistical value	*P* value	Confidence interval with the confidence level of 95%
Price of mechanized crop residue recycling	−0.503 487 4	0.126 540 7	−3.98	0	[−0.751 502 6, −0.255 472 2]
Recognition on crop residue recycling	0.530 510 9	0.102 816 7	5.16	0	[0.328 993 9, 0.732 027 9]
Whether it is adopted the previous year	1.382 754 0	0.273 055 5	5.06	0	[0.847 575 2, 1.917 933 0]
Proportion of working out	0.756 246 9	0.179 440 7	4.21	0	[0.404 549 6, 1.107 944 0]
Total number of family members	−0.235 267 7	0.118 019 2	−1.99	0.046	[−0.466 581 0, −0.003 954 4]
The price of coal	−0.006 826 5	0.003 230 6	−2.11	0.035	[−0.013 158 2, −0.000 494 7]
Whether there are animal living on grass	−0.699 573 3	0.337 080 0	−2.08	0.038	[−1.360 238 0, −0.038 908 6]
A constant term	32.162 090 0	8.617 448 0	3.73	0	[15.272 20, 49.051 97]

2.2 Explanation on important and significant variables

2.2.1 The price of mechanized crop residue recycling has significant negative correlation with rural households' behaviors on adopting crop residue recycling. Once the price of mechanized crop residue recycling reduces by 1yuan, the possibility of rural households adopting the technology will increase 10.07%. The higher the costs of mechanized crop residues recycling, the less rural households want to apply the technology. It is the results of rural households' expectation on maximum profits. According to the assumption of economic rational man, farmers will choose low-cost way to handle crop residues. When the costs of mechanized crop residues are lower than local labor prices, the behaviors of mechanized crop residues recycling will happen. The machinery subsidies can increase the quantity of machine and increase the competition among owners of agricultural machine, so as to abate the prices and encourage farmers to return crop residues to land.

2.2.2 The adoption of mechanized crop residues recycling in the previous year has positive effects on rural households' behaviors on adopting crop residues recycling technology. If rural households adopted the mechanized crop residues recycling in the previous year, the possibility that they will still apply the technology will increase by 27.85%. The results produced by using new technology in the previous year have great impact on whether rural households will adopt the technology at this period or not. Due to certain factors, rural households adopt the mechanized crop residues recycling, if the technology at the previous period has been mature and the effects of mechanized crop residues recycling were acceptable and in accordance with farmers; expectation, rural households will continue to use the technology at the last period.

2.2.3 Proportion of non-agriculture labor has significant positive effects on rural households' behaviors on applying crop residues recycling technology. Manually harvesting corn is labor consuming job. When the agricalture labors are insufficient for most people working out, rural households will tend to apply mechanized crop residues recycling technology. It implies that labor transfer is one of the factors that lead to the widely adoption of local crop residues recycling. The mechanized crop residues recycling has decreased the labor intensity and improved the fertility of farmland. Thus, the abandon of rural land caused by low agricultural interests and large labor intensity will happen.

3 Conclusions and suggestions

3.1 Conclusions The proportion of non-agriculture labor and whether applied mechanized crop residues in the previous year have positive effects on rural households' behaviors on mechanized crop residues recycling. The price of mechanized crop residues recycling has negative correlation with it. Machinery subsidy is an important lever for controlling price. The government can give subsides to farmers who bought agricultural machine to improve their willingness on buying the machine then, the increase the quantity of machines can lead to the decline of the price of mechanized crop residues recycling. In order to effectively subsidize the agricultural machine, the functions of the positive correlation variables should be fully displayed. Working out is the main trend and urbanization demands more labors. Whether applied the technology in the previous year affects household's decision in current technology adoption.

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3.2 Suggestions

3.2.1 Increasing machinery subsidy on crop residues recycling and abating the burden of masters of agricultural machine. The government should intensify the subsidies on crop residues recycling; improve the proportion of machinery subsidy; enhance the efficiency of subsidy; promote competition; lower the price of mechanized crop residues recycling and promote the application of mechanized crop residues recycling. Besides, through subsidizing oil price of agricultural machine, the burden of masters of agricultural machine will be alleviated. Under the permissive condition, the government should subsidize the rural households which return crop residues to land.

3.2.2 Intensifying the technical training on owners of agricultural machine and education on farmers. In order to ensure the circular use of mechanized crop residues, the government should provide technical training and vocational education to owners of agricultural machine and to ensure the fully display of the effects of mechanized crop residues recycling. In the meantime, the government should increase the promotion on the working mechanism, interests of increasing grain yield and increasing soil fertility of mechanized crop residues recycling to let farmers know the importance of mechanized crop residues recycling, so as to promote the long -term and effective use of mechanized crop residues recycling.

3.2.3 Promoting rural security system and decreasing the risks bought by rural labors transfer to rural areas. The government should guarantee the punctuate income of farmers to help farmers afford the costs of mechanized crop residues recycling. Besides, the government should perfect rural security mechanism to reduce the risks bought by the labor transfer to rural areas so as to ensure the factor of rural labor transfer on improving the fertility of rural soil.

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