

The Game Between Companies and Farmers in Controlling Pig Environmental Pollution

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Abstract

To reduce the waste pollution in the “company + peasant household” special cultivation mode, an effective countermeasure is to help farmers use waste to integrate planting with breeding. But considering the farm are not surrounding the pig farm, it exists long distance transportation of waste, and the household economic crops of every peasant are not unified. I also take into account of the planting and pest control technology as well as the final sales. Then the author puts forward four feasible schemes: The first is farmers use waste to grow their own crops, the second is the company contracts farmers land using waste to plant, the third is companies develop crops planting and using waste, the last is using the waste to cultivate crops by means of “company + peasant household”. Based on the theory discussion and game derivation of the four ways, I made the conclusion that “company + peasant household” mode is more effective to solve the problem. It realizes the symbiotic association of planting and breeding, not only can solve the problem of environmental pollution, but also brings a new profit growth point to the companies, and makes the farmers earn more income. More importantly, the scientific farming method can improve the utilization of resources and optimize the allocation of resources.

Key words: “Company + peasant household”; Farming combination; Game

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INTRODUCTION

In recent years, large-scale pigging has become the mainstream of the pig industry in China. Driven by providing employment opportunity for farmers and increasing farmers' income, the “company + peasant household” mode of pigging became popular. This win-win symbiosis model produced great synergies, but it also brings a series of environmental pollution problems. In this mode, every peasant household pigs independently in small size with poor breeding and poor facilities to handle the pollution. Farmers also have no extra money in pollution control and have less consciousness of environment protection. Therefore waste emissions at random. At the same time the company undertakes less social responsibility and the government do not supervise well, individuals are not concentrated, in turn, increasing the difficulties of the pollution treatment. Thus, for the pollution control in the “company + peasant household” mode, measures as site selection and planning, reasonable reduction production, controlling pollutants from the source, moderate cultivation are not applicable. In addition to increased government supervision, more practical and feasible way is to combine planting with raising to utilize waste and reduce the environmental pollution. Because the crops are not surrounding the pig farm, it exists long distance transportation problem of waste, involves crop cultivation and sale problems. How to implement the cultivated combination to realize the economic income and reduce the pollution at the same time has become a problem worthy of studying.

1. RESEARCH STATUS

1.1 Solutions of Waste Pollution in Large-Scale Pig

For the pig waste pollution treatment, different scholars put forward many constructive opinions:

Scaled pig waste are mainly used as fertilizer, feed, fuel and to cultivate edible fungi (Zhou, 2014).

Reasonable planning, appropriate breeding and farming, ecological farming, and control of pollution sources, reducing pollutants discharge in the feed (Zhang, 2014; Liu, 2014).

At present the most economic and suitable way to control pollution for China: Treating the pig manure as fertilizer to achieve the virtuous cycle of agriculture (Tang & Zheng, 2014).

Setting up the concept of circular economy, combining pig breeding with planting to achieve the unification of the economic, social and ecological benefits (Wu, 2014).

Combine planting with raising, in or beyond situ to use the waste, constructing the organic fertilizer factory (Zhang, Yin, & Li, 2015).

Establishing a perfect system of pollution prevention, setting up special regulators as well as strengthening the importance of environment protection to the publicity (Wang, 2015).

Tian, Lin and Duan (2015) studied anti-pollution measures of developed countries. For example in the United States collected dung often are returned to use by more advanced technology, German emphasis on farming moderately and in the form of law provisions that the pig farm waste must be returned at last. Denmark has done an environment-friendly modern pigging. Every pig farm must have the waste temporary pool matching with the farming scale in the law. And the waste must be returned to the soil after several months of fermentation processing.

Therefore, the measures to control waste pollution in the pig industry mainly are moderately reasonable location selection, breeding reduction, reducing output of pollutants, combination of pigging and planting, and ecological farming. But in the “company + peasant household” mode, the farmers raising pigs independently, reasonable location selection and moderate breeding are clearly not suitable. And reduction of breeding pollutants is based on advanced technology and abundant capital, so this measure is not applicable for the waste pollution prevention and control in the “company + peasant household” mode. Under the mode of “company + peasant household”, taking advantage of waste to cultivate is a good choice.

Lin mentioned if cultivation combined scientifically, comprehensive benefit can be improved by more than 20% (Zhang, 2015).

Applying the waste comprehensive treatment technology in 68 scaled pig farms of Fang chenggang in 2012, achieved annual increased output value 28.5589 million yuan, net income of 12.0134 million yuan and

achieving annual increased output value 28.5589 million yuan, net income of 12.0134 million yuan (Yan, Ling, & Yuan, 2014).

1.2 Research on Pollution Control in the “Company + Peasant Household” Mode

This paper mainly studies the environment management of waste pollution in the “company + peasant household” mode, however at present the research in this area is rarely. Southern daily reporter (2014) studied the different situations between companies and farmers in the “company + peasant household” mode. Specifically as for the modern large-scale farming company, waste residue can be an efficient organic fertilizer, black and stink waste can be clear and used for irrigation. The farmers only have simple pool, waste water usually directly discharge into the river, so the pollution is serious.

Investigating its reason, mainly farmers’ capital is insufficiency and has weak consciousness of the environmental protection. As is known to all, the prime motivation of the “company + peasant household” mode is more output with less investment. But if the enterprise equips all farmers complete environmental protection facilities, this advantage may be lost.

Based on the analysis of the above, cultivated combination to solve the waste pollution in the “company + peasant household” mode is an effective method, but due to the long-distance transport problem, this article will deduce the selection of waste management as well as solving the problems involving a long-distance transportation in the “company + peasant household” mode from the point of the game. This is also the innovation of this article.

2. WASTE TREATMENT SOLUTIONS

The problems: How to make use of pig waste not only meeting environmental requirement but also increasing economic benefits.

This problem is the balance between environmental protection and the interests, whether for farmers or for aquaculture companies, what they pursuit is profit maximization under environmental protection.

The solutions:

- a) Farmers grow their own crops using pig waste;
- b) Pig enterprises contracting farmers’ land to grow crops by using pig waste;
- c) Pig enterprises developing field to grow crops by using pig waste;
- d) Take the “company + peasant household” symbiotic mode in cultivating crops.

2.1 Farmers Grow Their Own Crops Using Pig Waste

Introduction: Under this scheme, farmers grow crops on their own land with certain experience of planting, hire themselves, sell alone and solve the waste transportation

problem. Farming enterprises basically don't participate in the cultivation without income. Only when farmers pollute the environment, will the enterprise bear joint liability. It includes possible opportunity cost of shutdown which influences production stability.

Analysis: In order to urge farmers to use pig waste reasonably, the government should enhance supervision and aquaculture enterprises also need to participate avoiding unnecessary loss. Farming enterprises also need to help farmers solve planting technology and sales problem, increase farmers' confidence in combination and the trust of the company. But with this solution, aquaculture enterprises have less control on the farmers. In addition, the waste used directly for crops may cause an adverse effect on the soil.

2.2 Pig Enterprises Contracting Farmers' Land to Grow Crops by Using Pig Waste

Introduction: Under this scheme, the pig enterprise contracts farmers' land and farmers as the company's staff grow crops. Accordingly, farming enterprises provide technical support and are responsible for sale. Breeding enterprise has strong consciousness of environment protection and its fame, as well has advanced equipment. Thus there is no pollution.

Analysis: Farmers' income is certain which can strengthen their confidence and avoid the opportunity cost. Cultivation is under the control of the company and there is no need to worry about sales. Farming enterprises can take advantages of scale effect to form their own transport team to solve the problem of long distance transportation, which requires higher management ability therefore increasing the risk. This pattern of win-win is dependent on advanced technology, solving the problem of long distance transportation and developing crop sales market with the minimum cost.

2.3 Pig Enterprises Developing Field to Grow Crops by Using Pig Waste

Introduction: Farming enterprises have other access to land, employ external staff and use the pig waste to grow crops, and they regard the cultivation of crops as a new business to comprehensively plan. Farmers grow in their own land. So the cost of shipping waste should be Shared by farmers and farming enterprises.

Analysis: In terms of crops, farming enterprises and farmers are separate. Transportation is the only link and its distribution is easy to cause disagreement. In addition, the breeding enterprise ought to consider whether it is worth carrying out a new business simply to solve the problem of pig waste.

2.4 Take the "Company + Peasant Household" Symbiotic Mode in Cultivating Crops

Introduction: The "company + peasant household" symbiotic mode is directly applied to the cultivation of crops. Companies sign contracts on planting with farmers,

provide seed, fertilizer, pesticide, technical services, recycle crops in the form of support valuation which guarantees the farmers' reasonable profit on average. Farmers submit certain margin, get seed, fertilizer, pesticide and other materials from the company in the form of charge to an account, cultivate according to the company's technical requirements and all are returned to the company's for sale after harvest. The crops value after deducting the material value is earned income of farmers. Under this mode, breeding enterprises and farmers is the cooperation relation, so they also need to share the transportation cost.

Analysis: "Company + peasant household" symbiosis model realizes resource sharing and complementary advantages, and achieves the long-term mutual benefit and mutual trust. The breeding enterprise tolerates market risk and guarantee the farmers' reasonable and stable income. Aquaculture enterprises must have certain core competitiveness at the same time, excellent in the internal management, good control of cost and the strong market development ability to withstand market risk.

3. THE GAME BETWEEN COMPANIES AND FARMERS

The four kinds of scheme provide reasonable placement for the pig waste and realize the combination of planting and raising, but exactly what kind of solution is the better choice? I will solve this problem from the point of the game (this article does not consider the breeding enterprise's income of selling the organic manure from generated waste outside).

3.1 Income analysis

Symbol explanation:

p The price of agricultural products;

p_1 The company pays to farmers in the "company + peasant household" mode; in general, $p_1 < p$;

q_1 The output when farmers grow individually;

q_2 The output when farmers cooperate with the company, the company has technical support, so $q_1 < q_2$; and assume that the output when the company develop land to grow crops is approximately equal to the production when the farmers cooperate with companies;

c_1 The cost when farmers grow crops alone;

c_2 The cost when farmers cooperate with the company, the company has technical support, so $c_1 > c_2$;

tr_1 The long distance transportation cost when farmers handle the waste;

tr_2 The long distance transportation cost when company handle the waste, as a result of scale effect, $tr_1 > tr_2$;

tr_3 The long distance transportation cost farmers bear when the company develops land to grow crops;

tr_4 The long distance transportation cost the company bears when the company develops land to grow crops, so $tr_4 + tr_3 = tr_2$;

- a Subsidies for pollution control;
- a_1 Subsidies for pollution control of the company when developing land to grow crops;
- a_2 Subsidies for pollution control of farmers when developing land to grow crops, $a_1 + a_2 = a$;
- f_1 The fines when farmers handle waste, if the treatment effect is good, f_1 can be 0;
- f_2 The fines when the company handle waste, assume that the company pays attention to image, so $f_1 > f_2$, likewise, f_2 can be 0;
- m The company pays to farmers for their land;
- s Farmers' wages payed by the company at crops growing season;
- o Other management fees;
- n Search costs for the company to develop land.

Under the four kinds of solutions, the company's and farmers' net income as follows:

The farmers grow their own crops using pig waste:

The company's net income $u_1 = 0$.

The farmers' net income $u_2 = p * q_1 - c_1 - tr_1 + a - f_1$.

The pig enterprise contracts farmers' land to grow crops using pig waste:

The company's net income $u_3 = p * q_2 - c_2 - m - s - o + a - tr_2$.

The farmers' net income $u_4 = s + m$.

The pig enterprise develops land for crops using pig waste.

The company's net income $u_5 = p * q_2 - c_2 - m - tr_4 + a_1 - o - n$.

The farmers' net income $u_6 = p * q_1 - c_1 - tr_3 + a_2$.

Cultivate crops in the "company + peasant household" mode.

The company's net income $u_7 = q_2 * (p - p_1) - tr_4 + a_1 - o$.

The farmers' net income $u_8 = p * q - c_2 - tr_3 + a_2$.

From the above, we can see that when the farmers use the pig waste to cultivate crops individually, the company's earning is 0. We assume that there is no natural disaster, the company has advanced technology and planting methods. Therefore, under the other three modes the income should be positive. So from the purpose of profit, the choice of the above four ways can be simplified as the pig enterprise contracting farmers land, developing the crops field, cultivating in the "company + peasant household" mode this three kinds of solutions.

3.2 The Game

After screening above, there are three elements in the company's feasible set A_1 (contracting farmers' land, developing crops field, "company + peasant household" symbiotic mode) while farmers' feasible set A_2 have two elements (acceptation, rejection). If farmers choose to cooperate with the company, the waste treatment problem is unified by the company, otherwise, the waste disposal problem is solved by farmers themselves.

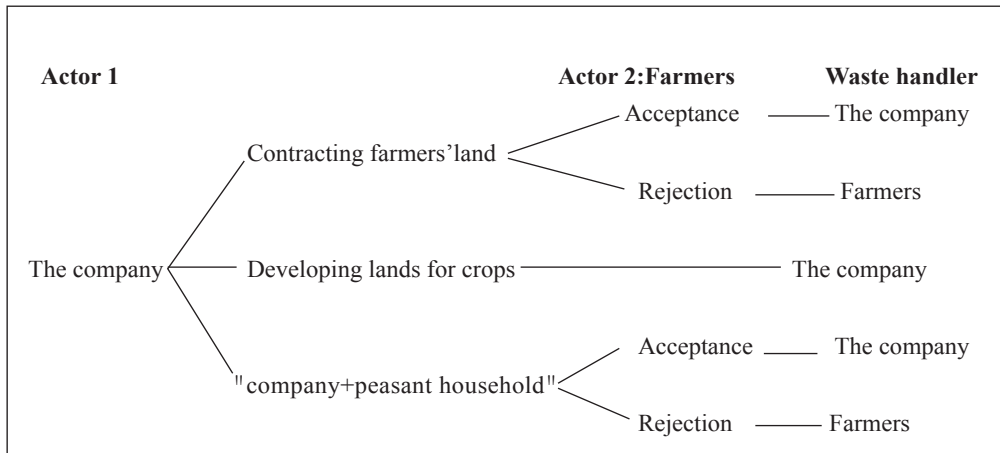


Figure 1
The Game Tree

The game between companies and farmers using backward induction is as follows:

First company choose a reasonable plan out of the feasible set A_1 :

When the company's selection is contracting the farmers' land, the income of farmers choosing to accept is $(s + m)$, choosing refusing is $(p * q_1 - c_1 - tr_1 + a - f_1)$. Due to the farmers' small income and poor anti-risk ability, we assume that the peasant households are risk aversion. So the utility of determined income is more than the uncertain

income which is influenced by the market price changes, natural disasters and so on. Therefore, when companies choose to contract farmers' land, farmers' optimal action is to accept;

When companies choose to develop crops planting, farmers' income of acceptance is

$$(p * q_1 - c_1 - tr_3 + a_2), \quad (1)$$

the income of farmers' rejection is

$$(p * q_1 - c_1 - tr_1 + a - f_1), \quad (2)$$

$$(1) - (2) = -tr_3 + a_2 + tr_1 - a + f_1, \quad (3)$$

Due to $tr_1 > tr_3$, $a > a_2$, governance subsidy is fixed and relatively small compared with the freight, so (3) > 0. Namely when the choice of the company is contracting farmers' land, farmers' optimal action is to accept;

When the company decides to adopt the mode of "company + peasant household" in cultivating crops, farmers' income of acceptance is

$$(p_1 * q - c_2 - tr_3 + a_2), \quad (4)$$

the income of farmers' rejection is

$$(p * q_1 - c_1 - tr_1 + a - f_1), \quad (5)$$

$$(4) - (5) = p_1 q - p q_1 - c_2 + c_1 - tr_3 + tr_1 + a_2 - a + f_1. \quad (6)$$

Since the production sensitive coefficient is more than the price sensitive coefficient when the company grow crops, $p_1 q - p q_1 > 0$. Because $c_1 > c_2$, $tr_1 > tr_3$, and the difference between a and a_2 is smaller, so (6) > 0. Namely when the choice of company is implementing "company + peasant household" mode for cultivation, the farmers' optimal action is to accept.

From the analysis above, we can conclude no matter which kind of schemes choosing from the feasible set A_1 , the optimal operation of farmers is to accept.

Now we go into the second phase of the game. On the condition that the farmers optimal action is to accept the case, I will sum up the optimal operation of the company in reverse.

Solution 1: Contracting farmers' land to grow crops

The company's net income

$$P * q_2 - c_2 - m - s - o + a - tr_2 \quad (7)$$

Solution 2: Developing lands for crops

The company's net income

$$P * q_2 - c_2 - m - tr_4 + a_1 - o - n, \quad (8)$$

$$(7) - (8) = a - s - tr_2 - a_1 + tr_4 + n. \quad (9)$$

Due to $(-s + n) < 0$, $(tr_4 - tr_2) < 0$, though $(a - a_1) > 0$, a is small. So (9) < 0. Namely (7) < (8), to the company, solution 2 is better than solution 1.

Solution 3: "Company + peasant household" mode for cultivation of crops

The company's net income

$$q_2 * (p - p_1) - tr_4 + a_1 - o, \quad (10)$$

$$(10) - (8) = P_1 q - p q_1 - c_2 + c_1 - tr_3 + tr_1 + a_2 - a + f_1. \quad (11)$$

Since the increase of production in the "company + peasant household" mode is more than the difference between the support value and the final price, $(P_1 q - p q_1) > 0$. We know $(-c_2 + c_1) > 0$, $(tr_1 - tr_3) > 0$, $(a_2 - a + f_1)$ is approximately equal to zero. Thus (11) > 0. Namely (10) > (8), to the company, solution 3 is better than solution 2.

To sum up, (10) > (8) > (7). Solution 3 is the best choice. So in the case that the optimal action for farmers is to accept, I conclude the optimal operation of the company for the cultivation of crops in reverse is the form of "company + peasant household" dealing with waste. In the end, the optimal solution of the game is (the "company + peasant household" mode for cultivation of crops and processing waste, acceptance).

SUMMARY

Pig in the "company + peasant household" mode achieves the win-win but also causes serious environmental pollution. Farmers' environmental protection consciousness is poor, and only have simple processing equipment causing the waste emissions. Because farmers live relatively scattered lack of reasonable planning and without considering the withstanding capability of the land, and with capital restrictions to reduce the generation of waste from the sources. Therefore, in addition to strengthening supervision and education, the author thinks that it is a reasonable and feasible method to combine the pig waste produced with cultivating crops. Considering waste long distance transportation, unified economic crops and the differences of planting technology, the author puts forward four kinds of raising combination of implementation scheme. Through comprehensive analysis, adopting the model of "company + peasant household" is more advantageous in crop planting. It not only solves the problem of environmental pollution, but also benefits farmers by solving the problem of their employment and increasing their income. At the same time, farming enterprises will also explore a new profit growth point. This is a win-win cooperation.

A lot of researches are for the pig waste pollution control while few in view of the "company + peasant household" mode. This article discusses the solution to implement the environment pollution control in the "company + peasant household" mode from plane to point, puts forward some countermeasures which enriches the theory and provides reference for breeding companies. At the same time, the innovation of this paper is using the backward induction method of the game theory to derive the most advantageous waste treatment scheme.

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