An Analysis of Governmental Economic Activities on Non-point Source Pollution Treatment in Rural Areas in China

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Abstract

In this paper we analyze all levels of government's activities in non-point source pollution treatment in rural areas from the perspective analysis of economics by starting from the economic characteristics of non-point source pollution in rural areas, besides, we discussed the dilemma between the rules and regulations of the central government when preventing and controlling the non-point source pollution in rural areas and the producers' behaviour which is protected by local governments. Thus we derive the government should reduce the direct administrative intervention, meanwhile by using more economical methods and incentive mechanisms which can control the input of natural resource and the output of the pollutants in the course of non-point source pollution treatment in rural areas, the market price system of green organic agricultural products will be formed, which will lead the behaviour of producers and consumers to beneficial to environment.

Keywords: Non-point source pollution; Market failure; Central government; Incentive-mechanism; Local governments.

1. Introduction

The so-called non-point source pollution is one kind of water environmental pollution, which is opposite to the point source pollution. The Amendment for American Clean Water Act (1997) defines it as "The pollutant enters the surface and the underground water body in a widespread, diffused, micro form." Here micro refers that the pollutant density is usually lower than the point source pollution, but the total loads are extremely huge. At present a more comprehensive definition is: Non-point source pollution "refers to the phenomenon that the dissolved and solid pollutants, which come from the non-specific place, with the washing action of precipitation (or snowmelt), afflux receiving body of water (including rivers, lakes, reservoirs, bays and so on) through the runoff process, and cause the water body eutrophication or other forms of pollution". Comparing with the point source pollution, the non-point source pollution has the characters of dispersibility and invisibility; randomness and uncertainty; not easy to be detectable and spatial heterogeneity. In fact, the non-point source pollution is more closely related with the agriculture, farmers and the countryside. Many people use agricultural chemicals, chemical fertilizer and the poultry manure of the small scale poultry cultivation excessively and unreasonably, as well as agricultural production cast-offs, village domestic garbage, waste water and so on that haven't been processed in rural areas, all of which are the direct factors of the non-point source pollution.

According to the statistics in 2004, the amount of chemical fertilizers applied has already reached 4637 million tons in China, and the amount of nitrogenous fertilizer occupies nearly 30% in the world.

The average amount of chemical fertilizer that is used in China is twice the amount of the safe upper limit of developed countries, but the average availability is only 40% or so. In this way the amount of chemical fertilizers in China will increase year by year, which are the main bodies that cause non-point source pollution in rural areas, besides the economic loss they create is unable to be counted. At present, due to applying fertilizer unreasonably in our country, there are more than 10 million tons nitrogen lost every year, whose direct economic loss is approximately 30 billion Yuan, what is more, the loss caused by the waste of agricultural chemicals is more than 15 billion Yuan. In the areas, which are influenced by agricultural pollution, there are crops underproduction, quality and taste reduction, flavor reduced, even in some places traditional crops are unable to continue to be produced. The pollution of the poultry-breeding farm will not only influence the areas around but also cause the epidemic transmission, which will make the cost higher. The agricultural pollution also causes economic loss in the fishery and animal husbandry tourism. In this paper we analyze all levels of government's activities in non-point source pollution treatment in rural areas from the perspective analysis of economics, and explore how the central authorities regulate the protection behavior of non-point source pollution producers who are protected by local governments, which will guide the production behavior of the producers and consumption behavior of consumers. Finally we can make the agricultural clean production come true and provide the environment support for the circular agriculture.

2. Economic analysis on preventing and controlling the non-point source pollution in rural areas of central authorities

2.1 Comparison of government's behavior

On the basis of law and regulations, recently developed countries adopt many kinds of economic and management researches and practice in protecting the rural environment especially in preventing and controlling non-point source pollution in rural areas.

2.1.1 Direct regulatory approach

The rural environment quality indexes established by the government will be enforced through the environment legislation. In this aspect, developed countries are earlier than us and they have obtained. In 1936, US formulated the first non-point pollution controlled act. In 1938, 1994, 1960 and 1970 it has been revised. In 1972 *Federation Water Pollution Controlled Act* (FWPCA) proposed clearly to control non-point pollution, and advocated "the best management practice" (BMPs) which is based on utilizing the land reasonably for the first time. On May 13, 2002, US have officially promulgated *Farm Security and Rural Investment ACT of 2002*. On July 12, 1999 Japan promulgated *Fundamental Law of Food, Agriculture, Countryside*, the goal of which is to accelerate the introduction of a higher long-enduring agricultural methods of production, guarantee the cooperation between the agricultural production and the natural environment, and realize the healthy development of agriculture. In the law it made explicit provisions for agricultural production to use compost and other organic market materials. *Compost Quality Law* was promulgated and implemented on April 1, 2001, according to the agricultural non-point pollution legal rules, the government also implemented *Law of Banning Agricultural Chemicals, Soil Pollution Preventing and Controlling Law* and so on one after another, the organic agricultural activities start to be carried out in metropolitan suburbs and the rural areas one after another. In 1975 the European Economic Community formulated the first environmental program of action, then in the Middle of 1980s, environmental policies of European Economic Community were further implemented through each program of action, especially EEA which became effective in July1987 provided the legal foundation for the environment. Therefore regulating directly is always the main and simple method to control the non-point pollution in rural areas.

2.1.2 Market-based incentive approach

Revised market mechanism should be used to protect environment. Although the social cost and personal cost of environmental products of non-point pollution in rural areas are not equal, which can not make effective resource allocation a reality, but with the changes of consumption ideas of consumers and the increasing demand for green organic foods, the prices are increasing; as various of subsidies and exportation quantity are on the increase, the producers apply less chemicals in production.

Meanwhile as the fertilizer technology and farm manure have been scaled and exportation rules of agricultural products in WTO have been changed, producers' cost signal will change too. Besides the production process won't keep the same as before, which will create less non-point source pollution in rural areas, but we need system innovation to solve the problem of market failure. There are two methods which may improve the rural environment quality by using market mechanism: One is to set up the market if there are no markets to sell rural environmental products. And establish the natural resource market, which is isolated from the outside by changing the property rights. The other is to revise the market mechanism, and make the administration section set the price which includes the completed social value of resources. Since rural areas of our country are in the transformation period of system reform, the market mechanism is imperfect, besides the non-point pollution in rural areas origins from the diverse areas, which are also dispersible. It is difficult to distinguish the geography boundary and the exact position, and the non-point source pollution also has characters of e randomness, complex reasons and long latent period. Therefore it is more difficult to solve the problem of externality by property rights definition.

To consider from the practice of preventing and controlling the non-point source pollution in rural areas of developed countries and the actual situation of China, we know that it is very difficult to complete the non-point source pollution in rural areas by a single method. With the coordination of the market mechanism and the law, it will be effective. The author thinks the reform goal of China is to achieve resource allocation on the basis of market finally, however, in market economy the cost of collecting non-point source pollution information and taking measures in rural areas is high, therefore the basic way is not to control directly, but to regulate by the government who will correct policies which do not comply with the development of environment and circular agriculture and make the market price system send out the correct signal to the people, thus we can achieve the goal of environmental protection.

2.2 General balanced model analysis of the best standard of pollution charges

With the intervention of governments, the key to make the market price system send out correct signals to the people is that, how the government can formulate the reasonable charge standard of pollution for the producer of non-point source pollution, on the basis of which we can make the Pareto optimality a reality. Using welfare economics,

we will analyze the effluent fee of non-point source pollution below.

2.2.1 Basic assumptions

We suppose that the production of agricultural products is of perfect competition, the production activities of general producers of agricultural products result in non-point source pollution (for example applying chemical fertilizer and agricultural chemicals excessively, poultry manure of small scaled poultry farming and so on) and the receivers are the consumers. The decisions of producers' economic activities will influence the contaminant extent, while consumption behaviors, production activities and the geographical position will influence the extent of damage.

Interpretations: in the model, r_i is total quantity of agricultural products of the whole society; s_k is non-point pollution concentration which is caused by producer k (for example agricultural chemicals, chemical fertilizer and so on); $Z = \sum s_k$ is the sum of all the concentration of non-point source pollution; $u^j(x_{1j}, \cdots, x_{nj}, z)$ is the utility function of consumer j; $f^k(y_{1k}, \cdots, y_{nk}, s_k, z)$ is the set of production. As the non-point source pollution is formed by multitudinous producers finally, the variable z should be involved in each consumer's utility function and the production group's production function. $u^j(x_{1j}, \cdots, x_{nj}, z)$ and $f^k(y_{1k}, \cdots, y_{nk}, s_k, z)$ is function of $(x1, \cdots, xm, y1 \cdots yn, z)$.

Essential hypotheses on convexity and concavity properties of functions: consumers' consumption set is both convex and closed, the utility function is twice derivable and the point of equilibrium will be utility maximization. Production function is twice derivable. The production function is a convex set, and the equilibrium is for profit maximization.

2.2.2 Fundamental model

In order to realize utility maximization, we choose a representative consumer: $U^1(x_{11}, \cdots, x_{n1}, z)$

Constraints: $U^j(x_{1j}, \cdots, x_{nj}, z) \geq U^{*j}$,

(j=2, ...,n) $f^k(y_{1k}, \cdots, y_{nk}, s_k, z) \leq 0$, (k=1, ...,n)

$$\sum_{j=1}^{m} x_{ij} - \sum_{k=1}^{h} y_{ik} \leq r(i=1, \ldots, n)$$

According to the hypotheses, we can use Kuhn-Tucker theory to describe the problem of maximization, and the Lagrangian equation is:

$$L = \sum \lambda_i [u^j(\bullet) - u^{*j}] - \sum \mu_k f^k(\bullet) + \sum_i w_i r_i - \sum_j x_{ij} + \sum_k y_{ik}$$

$$u_j^i = \frac{\partial u^j}{\partial x_{ij}} \qquad f_i^k = \frac{\partial f^k}{\partial y_{ik}}$$

In the condition of market equilibrium: To make utility maximization for the consumer equilibrium, Lagrangian equation is:

$$L_j = \sum p_{ij} + t^j + \alpha_j [u^{*j} - u^j(\bullet)] \quad (t_j \text{ is the tax rate of consumer j})$$

To make utility maximization for the enterprise equilibrium, Lagrangian equation is:

$$L_k = \sum p_i y_{ik} - t^k - t_s s_k - \beta_k \cdot f^k(\bullet) \quad (-t_s \cdot s_k \text{ is the total value of pollution tax of producer k})$$

The computation analysis above indicated the existence of externality of non-point source pollution and market equilibrium deviation from Pareto optimality. If Pareto optimality can be achieved, we must assess a tax from the men who produce external effect, which will make them take on the responsibility of the social cost of the effect. According to the computation analysis value above, if effluent charge of the non-point source pollution can be determined correctly, we can make the Pareto optimality of non-point source pollution which has a character of externality a reality by improving the market mechanism.

3 Game analysis on non-point source pollution treatment in rural areas between central authority and local authorities

3.1 Mechanism designing

The mechanism design formulates the gambling rules. In this paper we utilize dynamic game model with complete information to analyze the influence of central authority's behaviors on local authority's. The dynamic game mechanism with complete information is a staged dynamic game model, and we suppose that there are two participations: the central authority and the local authority. In the first stage, the client--central authority designs a choice mechanism, whose goal is to maximize his own expected utility function. In this game model, the objective function of central authority is to make the rural environmental protection come true, and to carry out the green agricultural production. We suppose that central authority chooses to punish the men (for example the one who uses agricultural chemicals and chemical fertilizer excessively) who produce non-point source production and were protected by the local authority at the degree of P, we also suppose the central authority collect effluent charge of the non-point source pollution and punish the polluters who are protected by local authorities to achieve the expected utility maximization and improve the environment. In the second stage, the local authority chooses the standards of the men who produce non-point source pollution to be protected, at the same time; the quantity of the producers who will be protected should be decided. The local authority regards the local performance, financial revenues and the employment as goals, which can be realized through the indexes of producers' gains level, besides due to the settlement of employment, and the reduced lowest cost-of-living allowance which is paid by local authority can be another index.

3.2 Fundamental model

Central authority's utility function is:

$$\text{Max } T = \pi t(Xe - Xp) - c - \gamma Xp \qquad (1)$$

In the formula, π is the enterprise profit, t is the effluent charge stipulated by the central authority, Xe is the total number of local agricultural product producers, and Xp is the number of producers who are protected by local authority. According to actual situations, these producers don't have to pay the effluent charges due to the protection of local authority. Assume that the outputs of agricultural products are in positive proportion to the amount of agricultural chemicals and chemical fertilizers used, γ is the ratio of the non-point source pollution which was produced by the protection of local authority, c is the cost of the central authority's supervision, the assumption is that central authority's degree of punishment will increase with the local authority's intensity, whose coefficient is θ, $c = \theta p$, $\theta \succ 0$. Here we analyze the protection behavior of the non-point source pollution of the local authority only, therefore only the producers who are protected are involved in the utility function.

Local authority's utility function:

$$\text{Max } U = t \int \pi(Xp)dXp + \int L(Xp)dXp - pXp \qquad (2)$$

In the formula, where $\pi(Xp)$ is the profit of a enterprise which is protected, $L(Xp)$ is the quantity of employment in the enterprise, and p is the punishment the government get for protecting the producers of non-point pollution.

First order optimality condition:

$$t\pi(Xp) + L(Xp) = P \qquad (3)$$

Meaning that financial revenue from producers who are protected by the local authority plus the lowest subsidy which the farmers live on from the local authority is equal to the marginal producers $X*$ who are suitable for central authority's punishment. Set of value of $X*$: the numbers of X in $\{X|t\pi(x) + L(X) \geq t\pi(X*) + L(X*)\}$. Obviously, Xp is decreasing for p $\left(\dfrac{\partial Xp}{\partial p} \prec 0\right)$. For the non-point source pollution has the characters of numerousness and randomness, the decreased number of the enterprises being protected which is caused by the cost of punishment is less than the increased number of producers who have been punished, therefore the function curve is convex to X axis ($\dfrac{d^2 Xp}{dp^2} \succ 0$), When $p = 0$, $Xp = Xe$, it means all the enterprises of the area are protected, then $Xp^* = \dfrac{Xe}{1+p}$, meanwhile, Xp is increasing for t, thus we set $Xp^* = \dfrac{Xe}{1 + p/t} = \dfrac{tXe}{t + p}$, which is the response function of local authority. For the central authority knows the response function of local authority, we put $Xp^* = \dfrac{tXe}{t + p}$ into (1), and we can get:

$$\max T = \pi t(Xe - \frac{tXe}{t + p}) - \theta p - \gamma\frac{tXe}{t + p}$$

$$s.t.c \prec \pi(Xe - Xp) \qquad (4)$$

First order optimality condition:

$$\frac{\partial T}{\partial p} = \frac{\pi^2 Xe}{(t+p)^2} - \theta + \frac{\gamma tXe}{(t+p)^2} = 0 \qquad (5)$$

$$\frac{\partial T}{\partial t} = \frac{Xe(\pi p - \gamma)}{(t+p)^2} p = 0 \qquad (6)$$

From (6) we get: $p* = \dfrac{\gamma}{\pi}$, put it into (5) can get:

$$t* = \frac{\theta\gamma}{\pi(\pi Xe - \theta)} \qquad (7)$$

We can see from $p*$ that the punish degree is positively related to the degree of non-point pollution caused by protection of local authority, is negatively related to the profit level. Many researches prove that, if the output of the agricultural products is positively related to the amount of fertilizers, comparing the organic model of agriculture production which doesn't need fertilizers with the model that need fertilizer, the output will decrease by 30% at least. In our country, this ratio is much higher, which make the central authority in trouble, therefore, when the central authority want to set up the penalty standard, he should call on the farmers to apply fertilizer reasonably, advocate non-point pollution treatment technology and the green consumption, set up green consumption market of organic agricultural products, though in this way the output is not positively related to the profit level and the income of the farmers is negatively related to the amount of fertilizer applied. Finally the non-point source pollution in rural areas can be prevented and controlled radically.

Observing from $t*$, tax rate and supervision cost of central government are positively related to protection intensity of local authorities and non-point source pollution that caused by protection, they are negatively related to the number and profit level of local producers. Profit level of agricultural products and numbers of enterprises of the area can be regarded as the symbol of economic development in countryside. So central authority has fewer penalties and regulation on the main regions where agriculture is developed faster, non-point pollution isn't obvious, and output is high, the behaviours of local authorities play a leading role in preventing and controlling non-point pollution in rural areas.

3.3 Predicament analysis on non-point source pollution treatment between behaviours of local authorities and central authority in rural areas

Though in our country from central authority to local authorities, the governments at all levels and environmental protection department all attach great importance to environment protection and pollution treatment, besides the efforts of each regulation and action is being strengthened constantly, however, the problem of non-point source pollution treatment in rural areas still moves slowly, from the perspective of economics, the efficiency of governments depends on the arrangement of administration structure and whether the targets are incentive compatible for officers, whether the designs of administration structure could encourage and restrain the behaviors of the official selfishness to reflect public interests. The roles of authorities in non-point source pollution are as below:

(1) Macro-control legislation, planning and coordination functions.

(2) Public rules and regulations function. The governments influence self-interest behaviors of other main bodies by using permits and formulating quality and technical standards, in this way they can protect the public environment in rural areas fully.

(3) Resource distribution function, meaning that public products for non-point source pollution are provided, but because of financial decentralization of authority pattern and the model for performance appraisal of local authorities and so on in our country, the administration structure of local authorities and incentive mechanism are not compatible, then the incentives of local authority's behaviors from control mechanism of central authority are twisted. With the influence of primitive development view, especially " nominal green GDP", regarding GDP as the center and advocating " Development means economy", producers' pollution behaviors in rural areas don't do bad to the official achievements, on the opposite, the more fertilizer they use the greater their financial achievements are, for the output of applying fertilizer is more than that of organic fertilizer, comparing the non-point pollution with the achievements, the local authority and producers of non-point source pollution agree on this point, which provides the foundation for the two.

4 Conclusions

The Systematic defects of non-point pollution in rural areas suggest that the government's insufficient ability of controlling the market. In order to control non-point pollution in rural areas and make the development goal of circular agriculture come true, the central authority has to change traditional intervention, find the root of market vacancy, correct Performance Indicator System of local authorities that is calculated by the increase of output and implement the green incentive mechanism. Besides to reform disadvantages for environmental protection rules and regulations and pay attention to the science and technical investment are indispensable. The government should reduce the direct administrative intervention, meanwhile by using more economical methods and incentive mechanisms that can control the input of natural resource and the output of the pollutants in the course of non-point source pollution treatment in rural areas, which will lead the behavior of producers and consumers to be environmental friendly and push the development of recycling agriculture.

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