A Supervision Contract Design of Electronic Products Manufacturers Controlling E-waste Pollution at Source under the Government and Consumers Supervising

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Abstract

The issue of government supervision to electronic products manufacturers was researched by principal-agent theory. Considered the potential gains of electronic products manufacturers affected by the consumers strengthening environmental protection consciousness, introduced the supervision cost and penalty, constructed the optimal incentive contract, and used these to establish a model which can maximize the expected revenue from governments. By analyzing the potential benefits from electronic products manufacturers and the validity of supervision mechanism from the governments department, the conclusion is found that the preference of green consumption can be the driving force for the manufacturers taking part in the activity of electronic wastes pollution control, so the roles for governments in electronic waste source pollution control is that impel and supervise the electronic products manufacturers, and the more measure is to inspire customers putting into effect green consumption, but the special attention should be paid to is that governments should designs appropriate punishment for electronic products manufacturers so that avoids ratcheting effect.

Keywords: *principal-agent, motivation, supervision costs, supervision*

1. Introduction

The Gui Yu event in Guangdong, Japan's Minamata Disease and Belgium's dioxin events all illustrates the extensive processing of electronic wastes give rise to these poor disposed wastes emits a large amount of harmful gases in the food chain and thereby threatening human health. These serious and major environmental issues not only arouse the public's recognition of environmental protection but also force governments to enhance the supervision and governance of electronic wastes pollution. Japan implemented "The policy and regulation of active recover and recycle personal computers" in 2003. During the same year the EU enacted "The law of EU's Electronic Wastes management" to strengthen the recycle and governance of waste electronic appliances. Until the June of 2008，27 states in America issued some related laws and regulations to prohibit the white waste household electronic appliances are abandoned at the garbage. In the 1st of July 2012, "The management methods for collecting and using the processing fund for the discarded electronic products" was first implemented in China, which precisely described the design plan of adopting comprehensive utilization of resource and harmless treatment as well as using environmentally friendly and easy recycling electronic products to reduce the fund. All these policies ensure the producerand consumer have greater responsibility for the safe disposal of products [1]. Nevertheless, the pollution control of electronic wastes is a complicated project and

difficult to be managed which need the positive cooperation of each aspect on different levels, so how to control the electronic wastes pollution effectively and how to keep the long-term and stable cooperative relation are urgent priorities and problems which should be resolved by the governments and enterprises nowadays.

Some scholars study the electronic wastes pollution control from enterprises' participation perspective. Savaskan [2] analyzed the structure selection problem of closed-loop chain and compares the advantages and disadvantages of three recycling modes. Ferrer [3] studied the decision problem of new manufacturing and remanufacturing. Chris coggins [4] considerd that the products' material and structure used in product design will directly determine whether the wastes can be easily recycling dismantling and whether the wastes will exert harmful effect to the environment. In other words, producers are the main source of electronic wastes who should take their responsibility for this situation. Krikke [5] and some other practitioners established a closed-loop supply chain model in the consideration of refrigerators' product design structure and proposed that product structure design should possess three traits: modular, easy to be maintained and recyclable. On the basis of material flow method, Lixia Su [6] and others built a resource cycle efficiency optimization model. In this model, two indicators which are the loop index and path length can be calculated through the substance of each code, which could reveal the optimize path of cycle efficiency. The research results demonstrate that green production and green design are effective approaches to improve resource recycling index, which of significant significance for improving the material recycling efficiency of the whole supply chain system.

In the actual operation, governments would like to consider and participate in the electronic wastes recycling from the following aspects: optimizing the investment environment, improving the quality of the environment, and enhancing governments' image. Some scholars have to study the reverse supply chain coordination under the guidance of governments. Wenbin Wang [7] established the electronic products recycling decision-making mode under the influence of rewards and punishment mechanism and discussed the condition of recycling and remanufacturing by manufacturer. Mitra and Webster [8] explored the influence of remanufacturing subsidies to the manufactures provided by the governments to get the result that the sharing of remanufacturing subsides by both manufacturers and remanufacturers can achieve the optimal results. Atasu and some other scholars [9] considered the economic and environmental influence and created a game model of governments, producers and customers and also take the consideration of the decision problem for the governments to provide the subsidies to manufacture as well as to guide them to recycle electronic wastes for reproducing.

Besides, the efficient conditions of legislation are also discussed. Wenbin Wang and Liqing Da [10] studied the wastes product recycling under the guidance of governments in the case of information symmetry, and design four types of rewards and punishment mechanism to analysis the coordination of reverse supply chain. Xianqian Wu and some scholars [11] used evolutionary game analysis the cooperative behaviors between manufactures and recyclers in the reverse supply chain in the case of government subsidies available. And they proposed that the amount of subsidies offered by governments should not be less than the cost of cooperation of manufactures.

Under the influence of market mechanism, because the focus of the electronic product manufacturers is profits maximization, so these enterprises tend to act short-term behaviors which may resulting in moral hazard. To solve the problem, some scholars

introduce principle-agent theory into the reverse supply chain' recycling incentive contract. Wang Xianyu and Jinjiang Yan [12] proposed the concept of state observer model and analysis the incentive supervision between principle and agent, but not take governments' supervision cost into consideration. Baoyin Zhang, Bo Wang and Yi Wu [13] created a model in which the governments is the principle and the enterprises is the agent, and assuming that based on the environment subsidies factors from the governments to encourage or punishment the enterprises' behavior in terms of influence the environment, but the sharing of governments' subsidies among the enterprises' supply chains and the influence of final product demand to the companies' profits. Mingming Ren [14] studied incentive mechanism design issue when the electronic manufacturers implement responsibility system in the case of the condition of both information symmetry and information asymmetry. Winwei Gong [15] attempted to investigate contract design problem of reversed supply chain in the case of information asymmetry by using the principal-agent theory and the revealed principle of screening game, and the contract design issue without the governments participation in the reversed supply chain and the contract design under the premise of rewards and punishment provided by the governments to manufacturers.

The above literatures have a significance influence to this study, but most of the literature is limited to the governments' motivation and guidance to the electronic products manufacturers, which does not involve an in-depth study of the combination of incentive and supervision mechanism. Besides, Consumers' environmental awareness and pressure coming from the regulations also urge enterprises to improve their environmental performance, especially in logistics activities [16]. For with the enhancement of customers' environment awareness, they tend to purchase environmental friendly products. So the enterprises should conduct more environment protection behaviors to win the recognition of the customers thereby gaining more economic efficiency. Klassen and Mclaugh [17] conducted an empirical analysis among the 162 companies to demonstrate a significant positive correlation between environmental performance and corporate profits, which show that a high environmental performance will bring the corporate more profits, by contrast, the low environmental performance will have a negative effect to corporate profits.

Due to its rapid industrialization, urbanization and modernization, China has become the world's top consumer of natural resource especially the raw material such as steel plastics and other minerals [18]. However, it's reported the solid waste from WEEE in china being three times greater than common waste [19, 20], about 20% of all e-waste in china is made of electronic appliances which growing at an annual rate of around 20% [21]. The current promotion of Chinese cleaner production strategies is mainly based on the Cleaner Production (CP) Promotion Law of the People's Republic of China, this law provided a favorable, prevention-oriented, political context, and assigned specific responsibilities among relevant governmental agencies and stakeholders to enhance its implementation [22]. And the regulations on take-back of End of Life products requirements and the associated financial responsibilities are vaguely defined, it gained popularity among the Chinese public in terms of its environmental concern. Although a multiple enforcement agency approach prevents full and effective enforcement of their leant legal requirements, China has satisfactory resources available to enforce reduction in environmental pollution at Chinese WEEE plants [23]. However, there are some challenges of implementing controlling waste at source, because it all depends on the understanding and willingness of leaders of enterprises, who consider economic and environmental benefits first [24], moreover, the economic risks are recognized as major

parts of the variance in the willingness of the firm to invest in CP practices and technologies. The perceived economic risks are related to social pressures with tighter governmental environmental standards [25, 26].So it's high time for the Chinese government to guide the enterprise to control the electronic waste. Based on the above background, this paper proposes the "Fixed & Sharing" incentive mode between governments and electronic products manufacturers. When enterprises take the social responsibility, the customer will more recognize and affirm the enterprises which bring potential benefits to the enterprises. So this paper adds the intrinsic factors for enterprises when they control the electronic wastes pollution which is also the innovation view of this paper. This paper takes the consideration of enterprises' short-term behaviors, introduces governments' supervision to the electronic products manufacturers, expands the penalty function and also establishes the governments expects revenue maximum model. Through the solution of this model, a result is obtained that companies' effort and customers' affirmation would provide more potential profits, and the relationship of various governments supervisions and the validity of potential benefits and supervisions are also discussed which reveal some important conclusion. Besides, this paper also offers a theoretical support and some practical approaches for the electronic product manufacturers to control the source of electronic wastes pollution.

2. The Model

2.1. The Basic Model Assumptions

The relationship between the governments and enterprises is principal and agent during the process of implementing controlling electronic waste at source, where the governments are principal and the enterprises are agents. The effort level of enterprises take part in controlling E-waste pollution at source is shown by a one-dimensional variable e, $e>0$. π_k denotes production function from direct economic benefits while π_l is the revenue function of governments.

$$\pi_k = ke + \theta_1, \pi_l = le + \theta_2$$

Where k is efficiency coefficient of output, including cost lower and price rising in relation to the implementation of E-waste Pollution Controlling at Source and $k \in R$, $k \geq 0$. In addition, E-waste Pollution Control at Source can also contribute to the environment changing, l stands for the environment changing factor, which $l \in R$, $l \geq 0$. θ_1, θ_2 are the random variables which have influence on the outcome of the electronic products manufacturers and they are subject to normal distribution, *i.e.*, $\theta_1 \sim N\left(0, \sigma_1^2\right)$, $\theta_2 \sim N\left(0, \sigma_2^2\right)$.

The electronic products manufacturers efforts allocation is not observable, in order to encourage the agents to take high efforts levels, the governments offer them an incentive scheme s, $s = \alpha + \beta\pi_l$ where α denotes the fixed fund that the governments offer technologies and talents for electronic managers to control the waste, while if the electronic manufacturers efforts can hardly satisfy the governments, and they will get the extra subsidies $\beta\pi_l$ from governments, β is the incentive intensity coefficient which shows how

the manufactures income changes with their efforts and $0 \le \beta \le 1$, if $\beta = 0$ implies electronic manufactures have no extra subsidies, if $\beta = 1$, the governments consider to offer the extra subsidies for the manufacturers because of the environment improvement. That is the "Fixed & Sharing" incentive mode.

Throughout the process of controlling electronic waste at source, there is a serious situation of information asymmetry between the electronic manufactures and the governments. The enterprises do more master a number of their own private information while governments hardly observe, which would make the enterprises be in the dominant position when cooperating. So the governments strengthen the regulation to cut down the information asymmetry degree. Supposing the supervisory cost function is $m(p) = m_0 p^2 / 2$. Where $m(p)$ is a real-valued, continuous, strictly increasing, m_0 is the coefficient of supervisory cost, $p \in [0,1]$ stands for the supervisory degree of the governments, in other words, it is the probability of the governments finding out the electronic manufactures whether fulfill the predetermined criteria, especially when $p = 1$, $m = m_0 / 2$, it is the highest level of supervisory expenditures[27]. If the outcome of the electronic manufactures equal or exceed the predetermined criteria, the electronic manufacture will get no punishment, otherwise they would get $(\pi_0 - \pi_l) f_0$ punishment from governments, so the penalized function can expressed like this:

$$f(\pi) = \begin{cases} 0 & \pi_l \ge \pi_0 \\ (\pi_0 - \pi_l) f_0 & \pi_l < \pi_0 \end{cases}$$

Here π_0 is the predetermined criteria, f_0 is the penalized ratio.

The governments is assumed to be risk neutral, and its utility function is u, the governments expected utility is equal to expected income: $u = \pi_l - s - m(p) + f(\pi)$

The expected benefit for governments is: $E(u) = (1-\beta)le - \alpha - m(p) + pf_0(\pi_0 - le)$

$c(e)$ denotes the cost of the enterprises' effort such as the cost of innovation design and using new product lines. In order to simplify the calculation, suppose the form of $c(e)$ is $c(e) = 1/2 be^2$. where b is the cost coefficient, and $b > 0$ standing for the enterprises' abilities for controlling waste at source, the bigger b is, the greater the negative effect of effort is. As the environment protection awareness of the consumers rise, the consumers have more preference on the green electronic products so that they will more recognize and affirm the enterprises who take part in controlling waste at source and the enterprises would get more potential benefits from the customers and sales volume enlarger, we define γ as this and $0 \le \gamma \le 1$. So we add the intrinsic factors for enterprises when they control the electronic wastes pollution at source, supposing v is the potential benefits and $v = \gamma \pi_l$, in fact, potential benefits lies on γ.

Above all, the real income of enterprises is: $w = \pi_k + s + v - c(e) - f(\pi)$

And the expected income for the enterprises is:

$$Ew = E(\pi_k + s + v - c(e) - f(\pi)) = (k + \beta l + \gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2$$

Assume utility function of enterprises is $\kappa(x) = -e^{-\rho x}$, which has a characteristic of

absolute risk aversion. Here ρ is the degree of absolute risk aversion, the expression of it is $\rho = -\kappa''(x)/\kappa'(x)$, x is the real income and subject to normal distribution, *i.e.*, $x \sim N(m, \theta^2)$. If $\rho = 0$, it means the enterprises are risk neutral, and if $\rho > 0$, it implies the enterprises are risk aversion while if $\rho < 0$, the enterprises are like risk.

Here the enterprises are assumed to risk aversion, according to Arrow-pratt, the risk expenditures of the enterprises is $1/2\,\rho(1+\beta+\gamma)^2\sigma^2$, so the certainty equivalent income of enterprises is:

$$Ew - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2 = (k+\beta l+\gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2$$

Defining ϖ is the conservative earnings of enterprises. If the certainty equivalent income is less than ϖ, the enterprises would not be interested in taking part in controlling waste at source. And they would passively assist the governments to carry out electronic waste controlling. Therefore, we can get participation constraint of enterprises' participating in controlling waste at source as follows

$$(IR) \qquad (k+\beta l+\gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2 \geq \varpi$$

The principal's problem is to choose an incentive scheme so as to maximize his utility subject to the agent's incentive constraint.

$$(IC) \qquad \max_e (k+\beta l+\gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2$$

2.2. Governments' Expected Revenue Maximization Model

Based on the above assumption, we can establish a model which can maximize the expected revenue from governments.

$$\max_{e,\beta} \qquad (1-\beta)le - \alpha - m(p) + pf_0(\pi_0 - le)$$

$$(IR) \qquad (k+\beta l+\gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2 \geq \varpi$$

$$(IC) \qquad \max_e (k+\beta l+\gamma l)e + \alpha - pf_0(\pi_0 - le) - \frac{1}{2}be^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2$$

3. The Solution and Discussion

Based on the degree of consumers' environmental awareness, the governments make a decision to supervise or not. We talk about some cases following.

3.1. Under the Condition that $p = 0, \gamma = 0$

In order to improve the environment, the governments have to make incentive scheme to conduct electronic manufactures to control waste at source for the environmental awareness of consumers is weak and have no help in potential benefits increasing. So the optimal effort level and incentive degrees are:

$$e_1 = \frac{k+\beta l}{b}, \beta_1 = \frac{l^2 - b\rho\sigma^2}{l^2 + b\rho\sigma^2}$$

3.2. Under the Condition that $p = 0, \gamma \neq 0$

With the environmental awareness of consumers arise, the potential benefits become obvious. The governments also provide an incentive scheme, so the optimal effort level, the internal coefficient, and incentive degrees are:

$$e_2 = \frac{k + \beta l + \gamma l}{b}, \quad \beta_2 = \frac{l^2 - b\rho(1+\gamma)\sigma^2}{l^2 + b\rho\sigma^2}, \quad \gamma_2 = \frac{l(l+k) - b\rho(1+\beta)\sigma^2}{b\rho\sigma^2 - l^2}$$

3.3. Under the Condition that $p \neq 0, \gamma \neq 0$

Considering the moral hazard problem of the enterprises, the governments make supervision on them. So the optimal effort level, the internal coefficient, supervisory and incentive degrees are:

$$e_3 = \frac{k + \beta l + \gamma l + p f_0 l}{b}, \quad \beta_3 = \frac{l^2 - p f_0 l - b\rho(1+\gamma)\sigma^2}{l^2 + b\rho\sigma^2}$$

$$p_3 = \frac{f_0 l^2 (1-\beta)}{m_0 b + f_0^2 l^2}, \quad \gamma_3 = \frac{l(l + k + p f_0 l) - b\rho(1+\beta)\sigma^2}{b\rho\sigma^2 - l^2}$$

4. Analysis

Proposition1. The effort level of enterprises is positive correlation with the enterprises gains, is negative correlation with the expenditure.

Observing from the forms of e_1, e_2, e_3, we can see that the numerators are what the enterprises get, including direct economic benefits, subsidy from the governments, intrinsic profits from consumers preference and the income deriving from penal rent saving, from controlling waste. The denominators are the effort cost of the enterprises. That is to say, the higher the total profits the enterprises get, the harder they take part in controlling waste at source. There is a negative correlation between the effort cost and effort level. The higher the effort cost, the lower the effort level.

Proposition2. With the internal benefits and supervisory degree improved, the effort level of the enterprises also increased.

Giving $e_3 > e_2 > e_1$, it is obvious that in the different case the effort level is higher and higher, there is $e_2 - e_1 = \gamma l / b$ meaning that without penal rent saving the enterprises would hard work for the intrinsic benefits from the consumers who make affirm and preference on the green products , we take the first partial derivative of e_2, e_3, $\frac{\partial e_2}{\partial \gamma_2} = \frac{\partial e_3}{\partial \gamma_3} = \frac{l}{b} > 0$ with respect to γ_i the showing result is positive. $e_3 - e_1 = \frac{\gamma l}{b} + \frac{p f_0 l}{b}$ showing under the governments supervision , in order to get the potential benefits and save penal rent, the enterprises work hard. That's because the governments can observe more action of the enterprises by supervision, the information asymmetry between the governments and enterprises is decreasing and the enterprises have no chance to be lazy. Taking first partial derivation of e_3 with respect to p_3, $\frac{\partial e_3}{\partial p_3} = \frac{p f_0}{b} > 0$, the result is positive, demonstrating supervision is useful.

The proposition 1 and 2 indicate that under the market mechanism, manufacturers' decisions are usually based on maximizing their own benefits .Not only can the direct profits make they positively participate in controlling waste at source but also the manufactures are afraid of punishment to pay penalty. In other words supervision is useful.

Propositon3. The incentive level the governments provide for the enterprises is lower with the intrinsic profit higher.

Define β_0 as the incentive coefficient that the governments offer for the manufactures in different cases, from the above equal $\beta_1 = \frac{l^2 - b\rho\sigma^2}{l^2 + b\rho\sigma^2} > \beta_2 = \frac{l^2 - b\rho(1+\gamma)\sigma^2}{l^2 + b\rho\sigma^2} > \beta_3 = \frac{l^2 - pf_0 l - b\rho(1+\gamma)\sigma^2}{l^2 + b\rho\sigma^2}$, we can get $0 \le \beta_0 \le 1$ and with the intrinsic profits increasing, the incentive coefficient $\beta_0 \to 0$. It also can be done by taking the first partial derivative of intrinsic benefits β_2, β_3 with respect to the incentive coefficient $\frac{\partial \beta_2}{\partial \gamma_2} = \frac{\partial \beta_3}{\partial \gamma_3} = -\frac{b\rho\sigma^2}{l^2 + b\rho\sigma^2} < 0$. It introduces that as the environmental awareness of the consumers highly improving the incentive cost the governments offer for the enterprises is lower. The enterprises are more willing to control waste at source for getting potential benefits from consumers. Generally speaking the incentive level the governments provide for enterprises is lower than without intrinsic benefits and supervisory. Especially when $\gamma^* = \frac{l(l + k + pf_0 l) - b\rho\sigma^2}{b\rho\sigma^2 - l^2}$, the incentive coefficient $\beta^* = 0$, the enterprises has full confidence in getting the potential benefits so the governments has no need to offer the enterprises incentive constrains only to provide some subsidies. On the other hand the intrinsic the enterprises get from the consumers has a close relationship with the degree of absolute risk aversion ρ , and the variances of the exogenous variables also contribute to it changing [28].

Proposition4. Incentive scheme and supervision plan are complementary. They all can be a way for the governments to guiding the enterprises positively to control the waste at source.

From the first partial derivative of p_3 with respect to β_3, $\frac{\partial p_3}{\partial \beta_3} = -\frac{f_0 l^2}{f_0^2 l^2 + m_0 b} < 0$ the result is negative. When the incentive level is higher and the supervision degree would be lower, on the contrary, it would be higher. The incentive scheme and supervision plan are complementary.

Proposition 3 and 4imply that the functions of the governments guiding the enterprises take part in controlling waste demonstrates on two aspects: one is the governments take the responsibility for retraining the enterprises and they have the right to incentive or penal even close the product if the enterprises has the wrong action, another is the governments take responsibility for rewarding the participator who protect the environment well, and they should be commended [29]. The governments should make clear about the intrinsic validity so that making the incentives and disincentives more reasonable.

Proposition5. The supervision degree is lower with the supervision marginal cost higher.

Differentiating the supervision level p_3 with respect to marginal supervision m_0 , $\frac{\partial p_3}{\partial m_0} = -\frac{bf_0 l^2(1-\beta)}{\left(f_0^2 l^2 + m_0 b\right)^2} < 0$ the result is negative, *i.e.*, p_3 is decreasing in m_0 indicating that the governments is unwilling to supervise for the high marginal supervision cost.

Proposition6. The supervision degree of governments is higher with the effort level of the

enterprises improving.

Generally speaking as long as the marginal effort cost decrease, the enterprises would positively take part in controlling electric waste at source, and in the meantime the supervision degree of the governments increase. We have first derivative $\frac{\partial p_3}{\partial b} = -\frac{m_0 f_0 l^2 (1-\beta)}{\left(f_0^2 l^2 + m_2 b\right)^2} < 0$, the showing result is negative, that is to say, p_3 is decreasing in b. The enterprises raise their working efficiency by using advanced technologies during the process in controlling waste at source so that the marginal effort cost of enterprises becomes lower. But considering the penal rent, the governments still makes supervision on the enterprises at this time and the supervision cost have not increase for using technologies, even so the governments can complement this expand by the income from the penal rent. If there is an unreasonable penal function, it might not be worth it financially, that's the ratcheting effect in the economic [30].

Proposition5and6indicates that the governments should take full account of incentive factors and supervision level, weighing the pros and cons carefully, to make a reasonable incentive scheme and supervision degree.

Proposition7. The risking cost which should be spent by the governments is saved for the intrinsic benefits increasing.

For the electronic manufacture, the environmental awareness of consumers enhancing bring more intrinsic benefits, decreasing the risk of the new product. We define ΔRC as the saving risk cost. From the equal $\Delta RC = \frac{1}{2}\rho\beta^2\sigma^2 - \frac{1}{2}\rho(1+\beta+\gamma)^2\sigma^2 = -\frac{1}{2}\rho\sigma^2(1+\gamma)(1+\gamma+2\beta) < 0$, the result is negative, implying the governments saved what they should have spent.

Proposition8. The expected benefits of the governments are increasing with the supervision level becoming higher at first, then the supervision level is at a fixed degree, the expected benefits begin to decrease, at the same time, the agency cost begin to raise. It will not be worth it if the governments still make supervision.

Making compared with supervision back and forth, the expected benefits of the governments is increasing, we can proof this by the equal $u' = le_3 - le_2 = \frac{f_0 l^2}{b} p$, but the governments spent $\frac{1}{2} m_0 p^2$, so the net profits are $u_0 = \frac{f_0 l^2}{b} p - \frac{1}{2} m_0 p^2$. From the result we can see the net profits take on moral "u" relationship with the supervision level. And then $p \in \left(0, \frac{2 f_0 l^2}{m_0 b}\right)$, the net profits are above zero. Form the conic treatment method, the governments will get the max net profits when the supervision is at level $p = \frac{f_0 l^2}{m_0 b}$. If the supervision level $p \in \left(0, \frac{f_0 l^2}{m_0 b}\right)$, the net profits will increase in p, otherwise if the supervision level $p \in \left(\frac{f_0 l^2}{m_o b}, \frac{2 f_0 l^2}{m_0 b}\right)$, the net profits will decrease in p. That's why the expected benefits of the governments is increase with the supervision level at first, when the supervision level is at a fixed degree, the expected benefits begin to decrease, at the same time, the agency cost begin to raise. It will not be worth it if the governments still make supervision.

5. Numerical Analysis

In the numerical analysis, we assume that $\rho = 3$, $\sigma^2 = 16$, $k = 50$, $l = 60$, $b = 0.4$, $f_0 = 30$, and the incentive level of government and enterprise effort level changes can be seen in these figures.

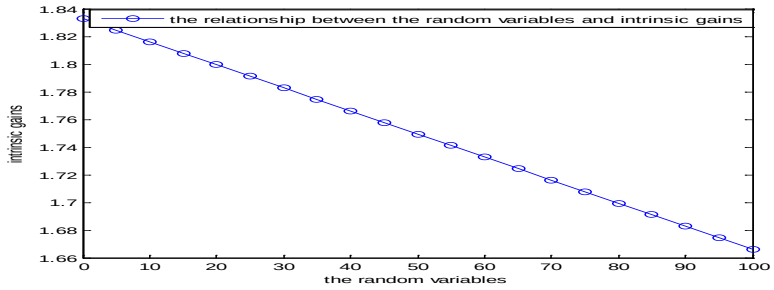

Figure 1. The Relationship between the Random Variables and Intrinsic Gains

In order to analysis the impact of intrinsic gains having on the incentive level, we show the relationship between random variables and intrinsic gains at first. The regression line in Figure1 reveals that with the random variables increasing, the intrinsic gains from consumers are decreasing. C. I. Hovland and I. L. Janis Pass researched the source of information, communication and situations would change consumer attitudes [33]. When green electronic products as new products enter into the market, consumers will assess them from all aspects such as availability factors, security factors and so on. So the governments and enterprises should set up publicity on the green electronic products to make consumers accept the new product easily. With the random variables decreasing, the intrinsic gains increasing.

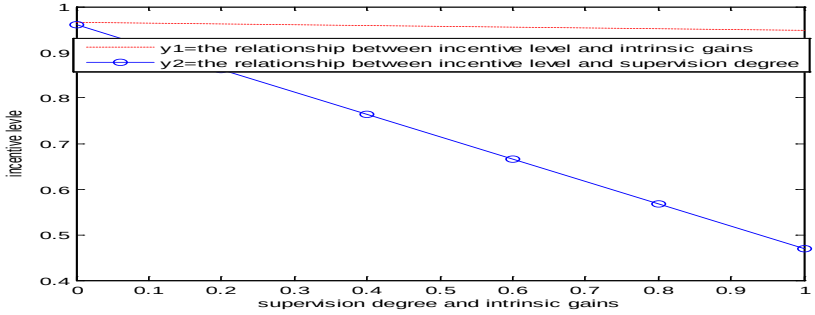

Figure 2.The Relationship among Incentive Level, Supervision Degree and Intrinsic Gains

Figure 2 reveals that due to the consumers' environmental awareness is a long process, with the intrinsic gains from the consumers rising, the incentive level is steadily decreasing, in order to motivate the enterprises, the government should also make a high level [31]. But with the government make supervision, the incentive has significantly reduced, it reflect incentive scheme and supervision plan are complementary.

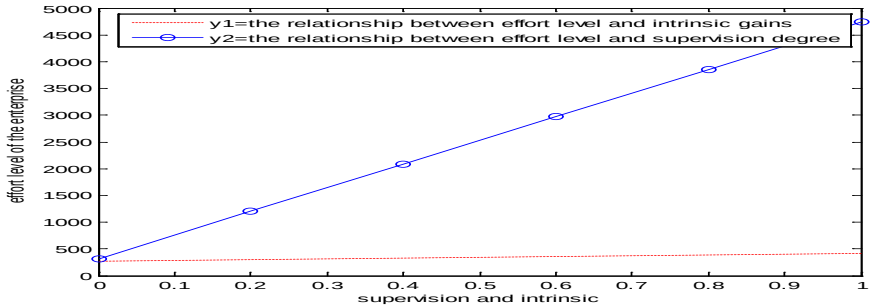

Figure 3. The Relationship among Effort Level, Supervision Degree and Intrinsic Gains

From the Figure 3, we can see that with the intrinsic gains from the consumers rising, the effort level is steadily increasing, that's because consumers' buying behaviors are affected by many factors, while the enterprises pursuit profit maximization , so the effort level is growth slowly without the supervision. When regulation is sufficiently stringent, enterprises work hard to avoid being punished [32].All these illustrate the enterprise is affected by the benefits when take part in controlling electronic waste at source.

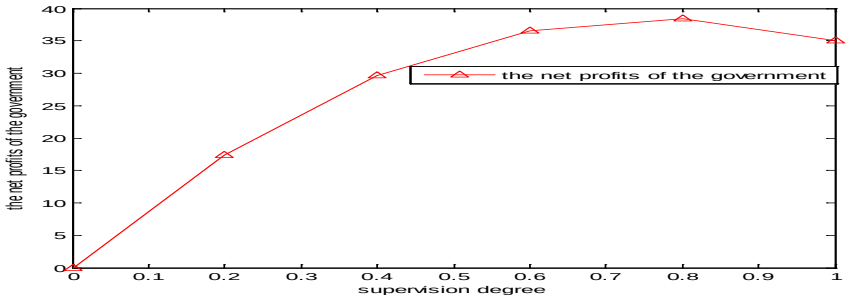

Figure 4. The Relationship between the Net Profits of Governments and Supervision Degree

According the proposition8, the result can be illustrated in Figure 4. The continuous lines present two possible inverted U-shaped relationships between net profits of governments and supervision degrees. The expected benefits of the governments is increase with the supervision level at first, when the supervision level is at a fixed degree, the expected benefits begin to decrease , and the agency cost begin to raise as the supervision cost is positive with the supervision degree. It indicates the government should make the proper supervision degree or it is not worth to make supervision [34].

6. Conclusions

In this paper we talk a problem about how the incentive levels of governments change with the environmental awareness of consumers different. Electronic waste controlling at source are series of transformation by designing product structure and producing lower pollution or easily dismantle products using the green material to satisfy the consumers for the need of new function. It is an inevitable choice for the manufactures to control electronic waste at source as the environmental awareness of the consumers rising and the governments makes great support on it. The relationship between the governments and the enterprises is principle

and agent, in order to encourage the enterprises positively to control the waste at source, the governments should not only use incentive scheme but also conduct a supervision plan and value the public opinion. This paper considered the potential gains of electronic products manufacturers affected by the consumers strengthening environmental protection consciousness, introduced the supervision cost and penalty, constructed the optimal incentive contract, and used these to establish a model which can maximize the expected revenue from governments. By analyzing the potential benefits from electronic products manufacturers and the validity of supervision mechanism from the governments department, the conclusion is found that first the effort level of the enterprises is positive correlation with what the enterprises gains and negative correlation with the expenditure, second the intrinsic profits from the consumer preference on green products is a internal dynamic for the enterprises participating the waste controlling at source, last incentive scheme and supervision plan are important ways for the governments in guiding the enterprises to control waste, but if the incentive and disincentive design unreasonable , it might not be worth it finally and the retching effect will appear. The governments should, taking full account of incentive profits, design the reasonable penal function so that make manufactures do work at best. While this paper only discuss the incentive and supervision problem between the governments and the enterprises. The benefits sharing among the retailers and recyclers are worthy topics for future researches. What exogenous variable distribution has impact on potential revenue is also an interesting topic and we will talk this in the other paper.

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