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Discussion on Optimal Allocation of Administrative Resources Used to Crack Down on Illegal Industry Chain

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Abstract

Illegal activities usually present industry chain characteristics, such as pornographic chain, piratical chain, oil-related illegal industry chain, and so on. Governments need to make heavy blows on illegal industry chains to maintain the healthy development of society and economy. As we all know, governmental blow activities need certain administrative resources. However different resource allocation modes cause different blow effects. This paper designed an optimal allocation model of administrative resources to purchase the maximum success rate of blow action subjected to certain administrative resources based on probability theory according to the characteristics of illegal industry chain.

Key words: Industry Chain; Administrative Resource; Optimal Allocation

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INTRODUCTION

Illegal industry chain is a similar concept with industry chain. It is a chain of illegal acquisition, illegal processing and illegal sales in an industry based on the industrial division of labor and internal supply and demand relation. There are upstream and downstream relations and the exchanges of value in the illegal industry chain as well, which shows the structure properties and value attributes. The essential difference between illegal industry chain and legal industry is that all the activities on the illegal industry chain are illegal, such as pornographic chain, piratical chain, oil-related illegal industry chain, and so on. From the angle of chain, we see that there are a lot of similar enterprises on each link of the illegal industry chain and each enterprise is on a certain link of the chain, and there are lots of exchanges of information, capital and materials between the upstream enterprises and the downstream enterprises[1].

In china, the illegal industry chains have disturbed the normal social and economic order. It is an important task for government to strike illegal industry chain and safeguard the healthy development of the market economy. However striking illegal activities will consume some regulation resources. So it is a vital social subject to study on optimal administrative resources allocation strategy under the guidance of efficiency for reducing consumption of regulation resources and improving regulation efficiency and strike effect according to the characteristics of illegal industry chain. This paper will make a research on this issue.

1. ESTABLISHMENT OF OPTIMAL ADMINISTRATIVE RESOURCES ALLOCATION MODEL USED TO CRACK DOWN ON ILLEGAL INDUSTRY CHAIN

As mentioned above, there exist upstream and downstream relations and value exchanges in illegal industry chain, thus the illegal industry chain would break if any junction of it is struck off. Usually law enforcement activities are carried out by government's different functional departments, or regulation departments. Every department of government plays certain role in law enforcement activities. When a government decides to crack down on illegal activities, it will appropriate certain resources to different departments. As we all know, different allocation methods lead to different law enforcement results. Normally, a department that can successfully detect more illegal activities with certain resources is regarded as a more efficient regulation department, while a department that can detect less illegal activities with equal resources is regarded as a less efficient regulation department. Comparing the more efficient regulation department with the less efficient one, we can easily see that the former can contribute more to regulation activities. According to the principle of efficiency, regulation resources should be allocated to the more efficient departments in order to crack down on illegal activities efficiently. Train of thought of administrative resources distribution among different regulation departments in order to crack down on illegal activities is shown in figure 1.

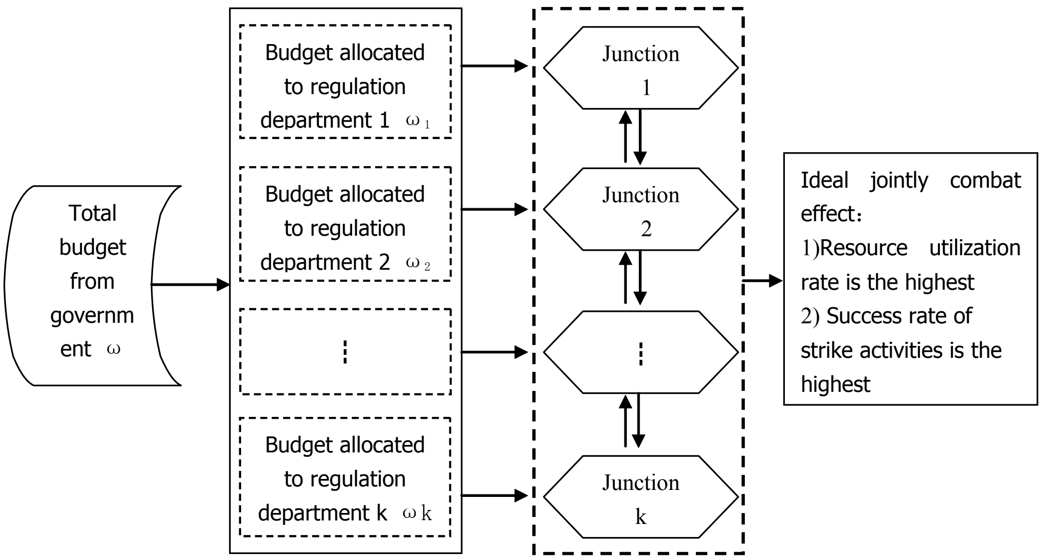

Figure 1
Thinking of Administrative Resources Distribution

In this article, government is marked by G which can be divided into regulation departments (e.g., police, judicial authority, administrative department for industry & commerce, bureau of quality and technology, bureau of environmental protection) according to different functions. Here we suppose that there are k regulation departments marked by $G_1, G_2 \ldots G_k$. There are only two possible results of each law enforcement activity: successfully detect illegal activities and fail to detect illegal activities. The ideal jointly combat effect on illegal activities is to realize that the resource utilization rate is the highest and the success rate of strike activities is the highest. We use n_i to represent the number of law enforcement activities, or law enforcement frequencies, of regulation department and m_i to represent the number of law enforcement activities that can successfully detect illegal activities in n_i, so $\theta_i(\theta_i = \frac{m_i}{n_i})$ represents detection rate of law enforcement activity. Obviously a greater θ_i means a higher probability of detecting illegal activities and a higher efficient law enforcement activity. The number of law enforcement activities carried out by G and the number of law enforcement activities that can successfully detect illegal activities by G can be calculated respectively as: $n = \sum_{i=1}^{k} n_i$ and $m = \sum_{i=1}^{k} m_i$, so $\theta = \frac{m}{n}$ indicates the detection rate of G. $(1 - \theta_i)$ is the probability of failing to detect illegal activities of regulation department. If a regulation department carries out n_i law enforcement activities, the probability of failing to detect any illegal activities is $(1 - \theta_i)^{ni}$. Along with the increase of n_i, the probability of failing to detect any illegal activities $(1 - \theta_i)^{ni}$ will become smaller. This reasoning is in accordance with the reality.

According to the principle of functional division in China government, regulation departments carry out their law enforcement activities in their own duty fields. So if several departments join in one action of law enforcement, the joint success rate, or the detection rate of successfully detecting illegal activities, of this joint action will be $1 - \prod_{i=1}^{k}(1 - \theta_i)^{n_i}$. If total regulation resources appropriated by government marked by w. Then under the constraint of ω, what we pursue is $\max P(n) = 1 - \prod_{i=1}^{k}(1 - \theta_i)^{n_i}$, that is, the maximum joint success rate of joint law enforcement activity.

Several hypotheses are put forward in this paper in the study of regulation resource allocation method:

(1) Assume that each illegal activity can be struck off thoroughly after being found.

(2) Each regulation department' detection rate of law enforcement activity can be obtained from historical data, which is a stable value.

(3) Each regulation department consumes the same quantity of resources in each law enforcement activity, which is marked by ω_i.

(4) The number of law enforcement activities (n_i, $i=1,2,\ldots,k$) of each regulation department is unlimited.

(5) Each department is indispensable, and it has to carry out at least one law enforcement activity, otherwise, it will lose its meaning of existence, so $n_i \geq 1$ ($i=1,2,\ldots,k$).

Based on the hypotheses we put forward above, the optimal allocation model of regulation resources (P1) can be written as follows:

$$\max P(n) = 1 - \prod_{i=1}^{k}(1-\theta_i)^{n_i} \qquad (1)$$

s.t. $\sum_{i=1}^{k}\omega_i n_i \leq \omega$, $n_i \geq 1$, n_i and ωi are integers, $i=1,2,\ldots,k$.

Optimization problem (P1) is an integer programming problem with a constrained nonlinear objective function, which can be transformed into an equivalent problem without affecting the optimal solution of the original problem. According to this thinking, the objective function is rewritten as:

$$\max P(n) = -\prod_{i=1}^{k}(1-\theta_i)^{n_i} \qquad (2)$$

s.t. $\sum_{i=1}^{k}\omega_i n_i \leq \omega$, $n_i \geq 1$, n_i and ωi are integers, $i=1,2,\ldots,k$.

The optimal solution after logarithm transformation of the objective function in formula (2) does not affect the optimal solution of the original problem, so the problem (P1) can be further rewritten as the following form:

$$\max -\sum_{i=1}^{k} n_i \ln(1-\theta_i) \qquad (3)$$

s.t. $\sum_{i=1}^{k}\omega i n_i \leq \omega$, $n_i \geq 1$, n_i and ωi are integers, $i=1,2,\ldots,k$.

To simplify the problem, let $\mu_i = -\ln(1-\theta_i)$, $i=1,2\ldots k$, obviously $\mu_i > 0$. Then problem P1 can be simplified as follows:

$$\max \sum_{i=1}^{k} n_i \mu_i \qquad (4)$$

s.t. $\sum_{i=1}^{k}\omega_i n_i \leq \omega$, $n_i \geq 1$, n_i and ωi are integers, $i=1,2,\ldots,k$.

Formula (4) can be further rewritten as follows:

$$\max \sum_{i=1}^{k} n_i \mu_i \qquad (5)$$

s.t. $\sum_{i=1}^{k}\omega_i n_i \leq \omega - \sum_{i=1}^{k}\omega_i$, $n_i \geq 0$ n_i and ωi are integers, $i=1,2,\ldots,k$.

This is an unbounded knapsack problem. Because the transformation process does not change the optimal solution of the resource allocation problem (P1), the solution method of P1 is given by dynamic programming as follows:

Assume that $P_i(S)$ is the maximum joint probability of successful detection of illegal activities including the latter $k-i+1$ law enforcement departments ($i,i+1,\ldots,k$). Where S is the regulation resources allocated to the $k-i+1$ law enforcement departments, and $w-S$ is the regulation resources allocated to the former $i-1$ law enforcement departments ($1,2,\ldots,i-1$). Obviously $P_1(\omega)$ is the maximum joint probability of successful detection of illegal activities including all law enforcement departments. Recursion formula can be obtained by simple calculation based on P1:

$$P_i(S) = \max_{n_i}\{1-(1-\theta_i)^{n_i}[1-P_{i+1}(S-\omega_i n_i)]\} \qquad (6)$$

Where value range of n_i is subject to $\omega_i n_i \leq S - \sum_{l=i+1}^{k}\omega_l$. Because regulation resources S must ensure that the latter $k-i+1$ law enforcement departments ($i,i+1,\ldots,k$) can carry out at least one law enforcement activity, the value range of n_i is:

$$1 \leq n_i \leq \text{int}\left(S - \sum_{l=i+1}^{k}\omega_l\right)\Big/\omega_i \qquad (7)$$

Where int( ) is used to get the largest integer. At $i=k$, the basic formula can be obtained as follows:

$$P_k(S) = \max\left[1-(1-\theta_k)^{n_k}\right] \qquad (8)$$

Where the value range of n_k is subject to

$$1 \leq n_k \leq \text{int}\, S/\omega_k$$

The optimal number of Law enforcement activities

($n^* = (n_1^*, n_2^*, \ldots n_k^*)$) can be obtained one by one by calculating $P_i(S)$, which is subject to:

$$\sum_{l=i+1}^{k} \omega_l \le S \le \omega - \sum_{i=1}^{i-1} \omega_i \quad (9)$$

Based on the above ideas, the dynamic programming algorithm can be obtained by the back recursive method. The dynamic programming algorithm is as follows:

Step 1: Arrange all regulation departments in order of θ_i / ω_i ($\frac{\theta_1}{\omega_1} \le \frac{\theta_2}{\omega_2} \le \ldots \frac{\theta_k}{\omega_k}$), $i = 1,2\ldots,k$, that is, a regulation department with a higher ratio of detection rate to resources needed in one law enforcement activity will be arranged in front of one with a lower ratio, which is in accordance with the principle of giving priority to efficiency.

Step 2: At $i = k$, if $S \in \left[\omega_k, \omega - \sum_{l=1}^{k-1} \omega_l\right]$, n_k can be obtained by formula (8).

Step 3: If $i = 1$, calculation is over; if not, let $i - 1 = i$, continue to the calculation of step 4.

Step 4: If $S \in \left[\sum_{l=i}^{k} \omega_l, \omega - \sum_{l=1}^{i-1} \omega_l\right]$, n_i can be obtained by formula (6).

Step 5: Back to Step 3

The number of law enforcement activities ($n^* = (n_1^*, n_2^*, \ldots n_k^*)$) in the above problem (P1) can be obtained by the dynamic programming. The efficiency-oriented allocation method of regulation resource mentioned above is called *optimal resource allocation method* in this article[2,3].

2. ADVANTAGES AND APPLICATION OF OPTIMAL ALLOCATION MODEL [4]

The administrative resource optimal allocation model used to crack down on illegal industry chain constructed in this paper distributes the remaining resources in order of law enforcement efficiency of regulation department on the premise that all regulation departments are secured to carry out at least one law enforcement activity, that is, the greater the value of $\frac{\theta_i}{\omega_i}$ is, the greater the priority of getting remaining resources is. This model considers both law enforcement effect of each functional department and cost of each law enforcement activity, and compares utility with cost, which is a matter of input-output efficiency.

The utilization rate of resource is indicated by η which is computed as:

$$\eta = \frac{\sum_{i=1}^{k} n_i \omega_i}{\omega} \quad (10)$$

It is not difficult for us to see that the value range of η is $(0,1]$. The closer to 1 the η is, the higher the utilization rate of resource is, and the fewer the idle or waste resource is. At $\eta = 1$, resource is fully used and no waste.

To illustrate, we suppose that A city is taking an joint law enforcement action to combat illegal activities, the number of departments involved in the joint law enforcement action is 7, 8, 9 or 10. q_i is subject to [0.0001, 0.2000]. The values of ωi are randomly generated from [20,100]. The amount of total resources appropriated by A city government is subject to $\omega = 2\sum_{i=1}^{k} \omega_i$

According to the dynamic programming idea, regulation departments are arranged in order of θ_i / ω_i ($i = 1,2\ldots,k$), and a department with a higher θ_i / ω_i is arranged in front of one with a lower θ_i / ω_i ($\frac{\theta_1}{\omega_1} \le \frac{\theta_2}{\omega_2} \le \ldots \frac{\theta_k}{\omega_k}$). Suppose that ten joint law enforcement actions are taken including two seven-department joint actions, two eight-department joint actions, three nine-department joint actions and three ten-department joint actions. The related data and allocation results are shown in table 1, table 2.

From the dynamic programming algorithm and the results in table 2, we can see that, as a matter of fact, the optimal resource allocation method focuses on regulation departments with higher detection rate of illegal activities and lower law enforcement cost, and allocates more resources on such departments, so that the effect of input-output reaches optimal. Under this optimal resource allocation method, more efficient departments are accessible to more resources, which is different from conventional egalitarianism approach and one-sided approach that pursues effect only without considering the cost. What is more, the average utilization rates of resources and the average success rates are 97.10%, 0.7113, respectively, which are satisfying as well.

Table 1
Related Data of 10 Joint Law Enforcement Actions

Joint action number	Detection rate of law enforcement of each regulation department $(\theta_1, \theta_2, \theta_3, \cdots, \theta_k)$	Amount of law enforcement costs of each law enforcement activity (thousand RMB Yuan) $(\omega_1, \omega_2, \omega_3, \cdots, \omega_k)$
1	(0.0653,0.0692,0.0506,0.0415,0.0428,0.0468,0.0312)	(38,46,35,30,33,40,31)
2	(0.0856,0.0890,0.0726,0.0718,0.0618,0.0662,0.0602)	(48,56,51,52,53,58,64)
3	(0.0756,0.0792,0.0634,0.0621,0.0518,0.0541,0.0402,0.0441)	(35,49,46,52,50,63,59,68)
4	(0.0556,0.0591,0.0532,0.0523,0.0416,0.0441,0.0413,0.0301)	(41,59,56,62,53,61,62,51)
5	(0.0442,0.0495,0.0452,0.0422,0.0306,0.0321,0.0303,0.0201,0.0199)	(29,35,36,37,33,41,42,31,32)
6	(0.0942,0.0925,0.0952,0.0812,0.0674,0.0901,0.0603,0.0501,0.0319)	(38,42,46,41,37,51,36,36,32)
7	(0.1045,0.0825,0.0856,0.0713,0.0664,0.0601,0.0503,0.0512,0.0232)	(40,42,46,41,44,51,46,47,32)
8	(0.0742,0.0721,0.0766,0.0653,0.0604,0.0511,0.0456,0.0432,0.0333,0.0201)	(27,28,32,31,32,29,30,29,32,26)
9	(0.0841,0.0861,0.0761,0.0752,0.0704,0.0618,0.0563,0.0432,0.0345,0.0218)	(42,51,46,50,54,53,49,46,45,40)
10	(0.0651,0.0661,0.0567,0.0532,0.0504,0.0458,0.0423,0.0512,0.0345,0.0378)	(39,51,49,50,54,52,55,76,59,65)

Table 2
Results of Law Enforcement

Joint action number	$n_1, n_2, n_3, \cdots, n_k$	η^*	P^*
1	(7, 1, 1, 1, 1, 1, 1)	93.03%	0.5333
2	(9, 1, 1, 1, 1, 1, 1)	95.62%	0.7115
3	(13, 1, 1, 1, 1, 1, 1, 1)	99.76%	0.7246
4	(11, 1, 1, 1, 1, 1, 1, 1)	96.07%	0.6169
5	(16, 1, 1, 1, 1, 1, 1, 1, 1)	98.86%	0.6315
6	(10, 1, 1, 1, 1, 1, 1, 1, 1)	97.63%	0.7943
7	(10, 1, 1, 1, 1, 1, 1, 1, 1)	96.27%	0.8004
8	(11, 1, 1, 1, 1, 1, 1, 1, 1, 1)	95.61%	0.7355
9	(12, 1, 1, 1, 1, 1, 1, 1, 1, 1)	98.53%	0.7976
10	(15, 1, 1, 1, 1, 1, 1, 1, 1, 1)	99.64%	0.7676
Average level		97.10%	0.7113

CONCLUSION

This paper studied the allocation problem of governmental administrative resources based on phase characteristics of illegal activities. The administrative resource optimal allocation model used to crack down on illegal industry chain activities constructed in this paper can distribute the limited resources to departments with the higher efficiency on the premise that all regulation departments are secured to carry out basic activities. It can use resources most efficiently, combat illegal activities as rigorous as possible, and deal with the problem of reasonable allocation of administrative resource in joint action. However this allocation model is built on some hypotheses, thus its application is limited to some degree.

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