Theoretical Analysis of the Optimal Decision of Information Sharing in E-Government Based on Public Economics

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Abstract: This paper divides e-government information resource into shared information (public goods), and reserved information (private goods). Then the connectivity coefficient of the exchanging platform in e-government is introduced to denote the extra cost caused by the incompatibleness of the platform. Then, this paper constructs an optimal decision model and discusses its Nash equilibrium and Pareto efficiency.

Keywords: electronic government; information sharing; the connectivity coefficient of the exchanging platform (CCEP); Nash equilibrium; Pareto efficiency

1 Introduction

Since 1990, with the rapid development of information technology and internet, e-government has become the focus of all countries. For example, UNDESA clearly deemed the e-government as the head of five applications in "information superhighway"[1].

In China, the construction of e-government has made initial achievements [2]. Nowadays, the focus of the Chinese e-government is gradually shifting to information sharing. However, there are lots of difficulties in the process of spreading information sharing in e-government, such as no information can be shared; reluctant to share information; information cannot be shared; no one shares first[3] [4] [5]. Indeed, the relevant state system is the main cause of these difficulties, but the system cannot be changed overnight. Thus, it is extremely significant to make optimal decision of e-government information resources sharing on predetermined conditions with limited resources.

E-government information resources have an attribute of "quasi-public goods"[6], but the fact underlying this attribute is that, the resources of e-government information is composed of two types of resources, which including both public goods and private goods. The cost, mechanism, utility of public goods is entirely different from those of private goods; therefore, in our research, we define the two sides of e-government information resources as shared information and reserved information, and regarded them as two state variables which are separately but also mutually restricted. By doing this, we establish a decision model to illustrate information sharing with the condition for limited resources.

2 Models

2.1 Hypothesis

Our model is based on the following assumptions:

1) About information

As we saw earlier, we suppose that the information is divided into reserved information (denoted by x_i in the following article) and shared information (denoted by g_i in the following article). Besides, although information has an ability of self-production, we ignore this attribute of information.

2) About the exchanging platform

The exchanging platform is offered by the municipal government. It is unnecessary for any region that is concerned to invest resources in building the exchanging platform. It means that $a\in[0,1]$ is an inner parameter. a is the connectivity coefficient of the exchanging platform(CCEP). The more completed the exchanging platform is, the easier for people to achieve information from the platform, and then a will be greater.

The amount of shared information that can be achieved by region i from the platform is proportional to both CCEP and the sum of shared information which is supplied by every region on the exchanging platform, that is to say, $\partial G/\partial \alpha > 0$, $\partial G/\partial G' > 0$. In these two inequalities, $G' = \sum_{i=1}^{N} g_i$ is the sum of shared information which is supplied by every region on the exchanging platform, and $G(a,G')$ is the amount of shared information which can be achieved by region i from the platform. We supposed that $G\left(\alpha, G'\right) = \alpha G' = \alpha \sum_{i=1}^{N} g_i$.

3) About region

Every region can obtain shared information only from the exchanging platform. We ignored other methods of information exchanging, such as the use of artificial transfer memory and peer to peer network transfer tools.

The goal of any region is to maximize $u_i(x_i,G)$ by way of rationally allocating invest of g_i and x_i with budget constraint M_i, and we assume that the budget M_i should only be invested in reserved information x_i and shared

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information g_i. $u_i(x_i,G)$ is the utility function of region i. Meanwhile, $\partial u_i/\partial x_i > 0$, $\partial u_i/\partial G > 0$, $\partial^2 u_i/\partial G\partial x_i > 0$, $\partial^2 u_i/\partial^2 x_i > 0$, $\partial^2 u_i/\partial^2 G > 0$.

2.2 Basic Model

We have established the optimal model of information sharing in e-government construction:

$$\begin{cases} \underset{g_i}{Max}\{u_i(x_i,G)\} \\ s.t.\quad M_i = c_x x_i + c_g g_i \\ \quad x_i \ge 0 \\ \quad g_i \ge 0 \end{cases}, \quad i = 1,2\cdots,n \qquad (1)$$

c_x is the cost of reserved information. c_g is the cost of shared information.

Then we conclude the condition for optimization:

$$MU_G/MU_x = c_g/\alpha c_x \qquad (2)$$

MU_G represents the marginal utility of shared information that region i can obtain, that is to say, $MU_G = \partial u_i/\partial G$; MU_x represents the marginal utility of reserved information that region i can obtain, i.e. $MU_x = \partial u_i/\partial x_i$

The situation which is represented by Eq. (2) can be showed by Figure 1.

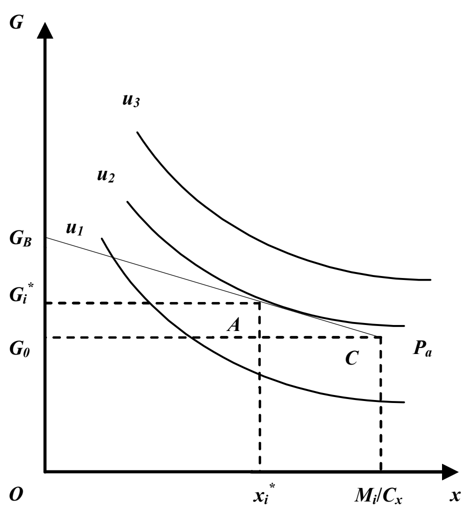

Figure 1. The optimal decision of utility maximization of region i

In Figure 1, curve P_a represents the possibility frontier of shared information that can be obtained by region i when it supplies a certain amount of reserved information with limited budget M_i. It has two end points called B and C. At end point C, region i invest M_i all in the construction of reserved information, and then the amount of reserved information it will obtain is M_i/c_x, and the amount of shared information it will obtain is $G_0 = \alpha\sum_{j=1,j\neq i}^{N} g_j$. At end point B, region i invest M_i all in the construction of shared information, so there is no reserved information left obviously, and the amount of shared information it will obtain is $G_B = G_0 + \alpha M_i/c_g$. u_1, u_2 and u_3 represent the equal utility curve of region i, obviously, $u_1 < u_2 < u_3$.

According to Eq. (2) we know, the point that represents the maximization of utility is the tangent point (point A) of equal utility curve and possibility frontier P_i. Here, corresponding reserved information and getable shared information are x_i^* and G_i^*. In other words, the amount of reserved information that region i invested is x^*, the amount of shared information that region i invested is $g_i^* = (G_i^* - G_0)/a$.

2.3 Extension model

In the basic model, we have supposed that the decisions other regions have made are known when region i is making decision. But in fact, we usually do not know decisions of others. So we suppose that the decisions of other regions are unknown when region i is making decision.

Then the extension optimal model is as follows:

$$\begin{cases} \underset{g_i}{Max}\{u_i(x_i,G)\} \\ s.t.\quad \sum_{i=1}^{N} M_i = c_x \sum_{i=1}^{N} x_i + c_g g_i \quad, \quad i = 1,2\cdots,n \\ u_j(x_j,G) = \overline{u_j}, j = 1,2,\cdots,N, j \neq i \end{cases} \qquad (3)$$

We also conclude the condition for optimization:

$$\sum_{i=1}^{N} \frac{\partial u_i}{\partial G}\Big/\frac{\partial u_i}{\partial x_i} = \frac{c_g}{\alpha c_x} \qquad (4)$$

From Eq. (4), we arrive at the conclusion. When the sum of marginal substitution rate of all the regions' reserved information and acquirable shared information equals the result that the cost of shared information divided by the product of CCEP times the cost of reserved information, the region i realizes its maximization of utility.

3 Conclusions

3.1 Conclusions of the basic model

The conclusions of the basic model are as follows:

1) In Eq. (2), when $a=1$, the compatibility of the exchanging platform is perfect, and the condition for utility maximization of region i changes into:

$$MU_G/MU_x = c_g/c_x \qquad (5)$$

This is the well-known Nash equilibrium condition in public economics consumption theory. In fact, there is a potential assumption in public economics consumption theory: the cost of goods exchanging is zero. But in this paper, how much shared information each region can obtain depends on a. Incompatibleness of the exchanging platform makes obtain shared information harder, and it virtually increases the cost of shared information. Therefore, when $a \neq 1$, we consider c_g/a as the unit cost of shared information which includes the extra cost brought by the incompatible of the exchanging platform, unit corrected cost of shared information for short. We use c_g' to represent the cost, then Eq. (2) changes into:

$$MU_G / MU_x = c_g' / c_x \quad (6)$$

2) The utility maximization of region i varies directly as a, at the same time, the shared information that region i can obtain will be increasing. As is shown in Figure 2, when a changes into a' (we supposed that $a'>a$), the unit corrected cost of shared information c_g' decreases, and the possibility frontier P_i moves from P_a to $P_{a'}$. Now the possibility frontier $P_{a'}$ is tangent to a higher equal utility curve u_3. As is shown in Figure 2, the optimal Nash equilibrium of region i moves to point D from point A. The corresponding reserved information and shared information becomes $x^{*'}$ and $(G_i^{*'}-G_0)/ a'$. Obviously, the utility of region i is greater now, and we will obtain more shared information, however, the change of reserved information is unknown. It depends on the degree of income effect and substitution effect that derive from the reduction of unit corrected cost.

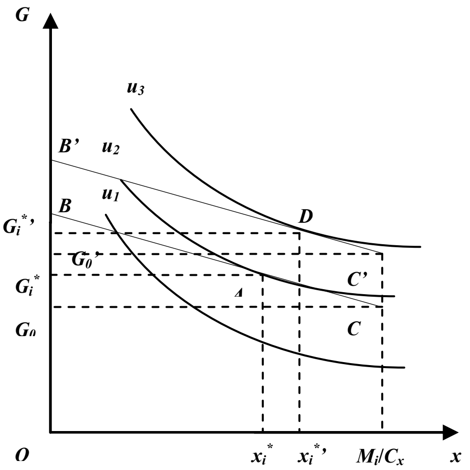

Figure 2. The change of optimal decision of region i when α increases

According to similar analysis, we can draw the locus of Nash equilibrium point, when a varies from 0 to 1. The locus is curve MNR in Figure 3.

Especially, when $a=0$, the Nash equilibrium point is $M(M_i/c_x, 0)$, meanwhile, $g_i=0$, $x_i=M_i/c_x$, it means that all the budget is used to invest in reserved information. When $a=1$, maximum of shared information $G_{max} = \sum_{j=1,j\neq i}^{N} g_j + M_i / c_G$, meanwhile, the Nash equilibrium point is $R(x_i^{a=1}, G_i^{a=1})$, it means that region i invest $x_i^{a=1}$ in reserved information and $G_i^{\alpha=1} - \sum_{j=1,j\neq i}^{N} g_j$ in shared information.

3) By the same method, we can find out all optimal decisions of every region. We figure out the optimal amount of shared information that every region supplies: $g^*=(g_1^*,...g_i^*,...g_n^*)$, and then the amount of shared information that the whole society can obtain is $G^* = \alpha \sum_{i=1}^{N} g_i^*$, at last the maximization of utility of each region is $u_i^*=(x_i,G^*)$, and the total utility of city X is $u^* = \sum_{i=1}^{N} u_i^*$.

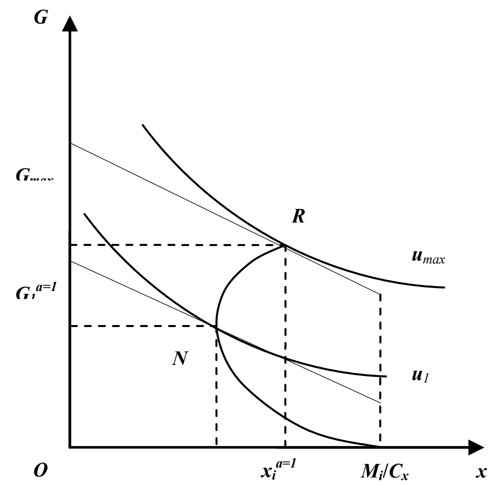

Figure 3. How optimal decision of region i varies with α

3.2 Conclusions of the extension model

By discussing the extension model, we come to following conclusions:

1) Supposed that $a=1$, then the condition for maximization of utility changes to Eq. (7):

$$\sum_{i=1}^{N} \frac{\partial u_i}{\partial G} \bigg/ \frac{\partial u_i}{\partial x_i} = \frac{c_g}{c_x} \quad (7)$$

It is the well-known Samuelson condition for Pareto efficiency in public economics (Samuelson, 1954). Parallel to the discussion in original model, we use $c_g'=c_g/a$ to represent unit corrected cost of shared information. Then Eq. (7) changes to:

$$\sum_{i=1}^{N} \frac{\partial u_i}{\partial G} \bigg/ \frac{\partial u_i}{\partial x_i} = \frac{c_g'}{c_x} \quad (8)$$

2) Unit corrected cost of shared information c_g' decreases when a increases. The conclusion is the same with the one in static model.

3) Eq. (10) can be transformed to:

$$\frac{\partial u_i}{\partial G} \bigg/ \frac{\partial u_i}{\partial x_i} = \frac{c_g}{\alpha c_x} - \sum_{j=1,j\neq i}^{N} \frac{\partial u_j}{\partial G} \bigg/ \frac{\partial u_j}{\partial x_j} \quad (9)$$

Compared Eq. (9) with Eq. (2), the ratio of the

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marginal utility of acquirable shared information to the marginal utility of reserved information when it is Pareto efficiency is smaller than the ratio when it is Nash equilibrium. Because $\partial u_i / \partial x_i > 0$, $\partial u_i / \partial G > 0$, $\partial^2 u_i / \partial G \partial x_i > 0$, $\partial^2 u_i / \partial^2 x_i > 0$, $\partial^2 u_i / \partial^2 G > 0$, the region in the case of Pareto efficiency will supply more shared information and invest less reserved information than it in the case of Nash equilibrium when all condition are same (e.g. CCEP, the budget constraint of informationization).

4) We can figure out all the optimal decisions of every region according to Eq. (3) and the total utility of city X called $u^{*'}$ when city X is in the case of Pareto efficiency. It will be seen from knowledge of public economics that solving Nash equilibrium is a personal optimization and solving Samuelson condition for Pareto efficiency is a social optimization. This kind of total utility is greater than the one that is acquired by solving Nash equilibrium, i.e. $u^{*'} > u^{*}$.

4 Discussions

Combining the conclusions above with Chinese e-government construction status of sharing information resources, we propose the following recommendations:

(1) To give full consideration to the compatibility of exchanging platform. The compatibility will indirectly influence the cost of supplying shared information, and come to influence the optimal decision of utility maximization. Therefore, in the process of constructing e-government, we should take CCEP into account when we are making optimal decision of utility maximization.

(2) To establish team of government departments with high comprehensive quality. The necessary condition for achieving utility maximization of the whole system is that all decisions made by subsystem fit on the Samuelson condition. It is a kind of knowledge which is strongly theoretical. In order to comprehend this theory and apply it in practice, the staff of government departments must master corresponding knowledge about public economics.

(3) To set up an exchanging platform of good compatibility. The better the compatibility of exchanging platform is, the higher CCEP is. And then, the total utility will reach maximum under the given budget constraints.

(4) The construction of e-government should insist on the principle that the top of the government programs the whole project. In the process of dynamic decision-making, the decision-maker should adequately take decisions of others into account, so it is a process of integral optimization. However, in practice, not all subsystem does that. If the top of the government programs the whole project and restrict the subsystem with administrative methods, the whole system would achieve dynamic optimization.

(5) To recognize clearly the relationship between the compatibility of exchanging platform and the input of shared information itself. We will achieve shared information resources easier when the compatibility of exchanging platform is better. But it does not mean that this will increase the input of shared information, the final change of input depends on substitution effect and income effect. Therefore, we cannot increase the input of shared information blindly if the compatibility of exchanging platform is good, and vice versa.

In this paper, based on the initial model, we take into account the "quasi-public goods" attribute of e-government information resources and the compatibility of exchanging platform, and this kind of consideration makes the model more rational.

Of course, there still problems exist in this model. For those unsolved problems, we will conduct for further analysis and discussion in other work.

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