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RESEARCH ON THE THREE-PARTY EVOLUTIONARY GAME MODLE AMONG THE GOVERNMENT, ENTERPRISES AND THE SOCIETY IN CORPORATE SOCIAL RESPONSIBILITY

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ABSTRACT

With the deepening of the research on the issue of corporate social responsibility, the relationship among the government, enterprise and society has become the hotspot of researches. It has great practical significance to analyze the dynamic game relationship among the three parties under the incomplete information condition. Based on this, the three-party evolutionary game model under the incomplete information condition and the hypothesis of bounded rational participants has been built, and the behavioral strategies and earnings of the three-party participants as well as the evolutionarily stable strategy have been analyzed. Besides, the three-dimensional stereogram is applied to demonstrate the gradually progressive trend of different strategy profiles; and the game results suggest that the government chooses the intervention strategy, enterprise chooses the social responsibility fulfillment strategy, and society chooses the supervision strategy reaches the optimal status of the model, and can better promote the enterprise to fulfill social responsibility.

Keywords: Social Responsibility, Evolutionary Game Model, Replicator Dynamics, Stable Strategy.

1. INTRODUCTION

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Corporate social responsibility theory has won its reputation among all sectors since it was prosed by Oliver Sheldon who thought that corporates should not only target at earning money for survival and development, but also bear stakeholders' requests in mind and shoulder social responsibility [1-2]. However, China acts poor in social responsibility and eats out people's expectation on it. Lack of corporate social responsibility is the culprit of food safety problem, safety production problem, social trust crisis, labor-capital conflict, wealth disparity, environment degradation, etc. All of these are worse enough to stunt enterprises' development and social harmony. In such context, this paper uses evolutionary game theory to construct a three-party evolutionary game model among the government, enterprise and society in corporate social responsibility.

Evolutionary game theory has been mature through efforts of domestic and foreign researches such as Smith [3], Friedman [4], Tadj, Touzene [5], Sun Qingwen [6], etc. It contains two basic concepts: Evolutionary Stable Strategy-ESS and Duplicate Dynamic Equation [7-9]. It is a departure from traditional Game theories in which people are reasonable and information is completed. Rather, it takes a more practical perspective to explain economic phenomena. There is no dearth of researches interested in the study of Evolutionary game theory. But few managed to apply it to the study of stakeholders of corporate social responsibility. More often than not, they just focused on two Game bodies and neglected that there were cases where three bodies competed with each other. In the three-party game among government, enterprise and society, the decision made by anyone will influence over the rest two. Therefore, this paper constructs a three-party evolutionary game model for better analyzing and predicting the Game [10].

2. PAPER LENGTH THE CONSTRUCTION OF THE THREE-PARTY EVOLUTIONARY GAME MODEL AND ITS PRESUPPOSITION

Direct stakeholders of corporate social responsibility are the government, enterprises and the society. The strategies of enterprises are either performance of social responsibility or non-performance of social responsibility. The strategies of the government are either intervention performance of corporate social responsibility or non-intervention performance of corporate social responsibility. The strategies of the society are either supervision of social responsibility performance or non-supervision of social responsibility performance. Each of the three takes on each other and adjusts its behaviors. Under incomplete information, they may not reach the maximum profit. But by learning and imitating, they optimize their benefits step by step.

There are eight Game combinations, namely, (intervention, performance, supervision), (intervention, performance, non-supervision), (intervention, non-performance, supervision), (intervention, non-performance, non-supervision), (non-intervention, performance, supervision), (non-intervention, performance, non-supervision), (non-intervention, non-performance, supervision) and (non-intervention, non-

performance, non-supervision). Out of convenient reason, set up relevant parameters [11], as shown in Table 1 (all of them are positive).

Table 1. Main parameters and their implications

Parameter	Implication	Parameter	Implication
C_1	Cost of government's intervention on enterprises	F	Quantitative indicator of negative influence that non-performance enterprise is exposed to social supervision
C_2	Cost of performance of corporate social responsibility	G_1	Quantitative indicator of negative influence that enterprise's non-performance of social responsibility brings to the government
C_3	Cost of the society's supervision on enterprises	G_2	Quantitative indicator of negative influence that enterprise's non-performance of social responsibility brings to the society. It is relatively high.
R_1	Benefits from government intervention of corporate social responsibility	G_3	Quantitative indicator of positive influence that enterprise's performance of social responsibility brings to the government
R_2	Economic profits from the performance of corporate social responsibility	G_4	Quantitative indicator of positive influence that enterprise's performance of social responsibility brings to the society. Suppose it is small
R_3	Quantitative indicator of positive effect of the society's supervision on enterprises	R_4	Incentives that the government gives enterprises for their performance of corporate social responsibility
M	Economic benefits from enterprises' saving costs by non-performance of social responsibility	R_5	Incentives that the society gives enterprises for their performance of corporate social responsibility
S_1	Quantitative indicator of negative effect on the government because of the government's non-supervision	W_1	Quantitative indicator of positive influence that the government's performance intervention brings to the society
S_2	Losses of enterprises because of non-performance of social responsibility	W_2	Quantitative indicator of negative influence that the government's non-performance intervention brings to the society
S_3	Quantitative indicator of negative effect on the society because of the society's non-supervision	P_1	Quantitative indicator of positive influence that the society's performance supervision brings to the government
D	Fines on enterprises from the government for non-performance of social responsibility (D> C_2)	P_2	Quantitative indicator of negative influence that the society's non- performance supervision brings to the government

According to Table 1, when the combination is (intervention, performance, supervision), the intervention cost of the government is C_1; benefits from government intervention of corporate social responsibility is R_1; positive influence that the society's performance supervision brings to the government is P_1; positive influence that enterprise's performance of social responsibility brings to the government is G_3; cost of performance of corporate social responsibility is C_2; economic profits from the performance of corporate social responsibility is R_2; positive influence that enterprise's performance of social responsibility brings to the government is C_3; positive effect of the society's supervision on enterprises is R_3; positive influence that enterprise's performance of social responsibility brings to the society G_4. When the combination (intervention, performance, supervision), the benefits of the government, enterprise and society are $-C_1+R_1+G_3+P_1$, $C_2+R_2+R_4+R_5$, $-C_3+R_3+G_4+W$ respectively.

Table 2. Benefits of other combinations are shown.

Government benefits	Enterprise benefits	Society benefits
$-C_1+R_1+G_3+P_1$	$-C_2+R_2+R_4+R_5$	$-C_3+R_3+G_4+W_1$
$-C_1+R_1+G_3-P_2$	$-C_2+R_2+R_4$	0
$-C_1+R_1+D-G_1+P_1$	$M+-S_2-D-F$	$-C_3+R_3-G_2+W_1$
$-C_1+R_1+D-G_1-P_2$	$M+-S_2-D$	$-S_3-G_2+W_1$
0	$-C_2+R_2+R_5$	$-C_3+R_3+G_4$
0	$-C_2+R_2$	0
$-S_1-G_1$	$M-S_2-F$	$-C_3+R_3-W_2$
$-S_1-G_1-P_2$	$M-S_2$	$-G_2-W_2-S_3$

3. ANALYSIS OF THE GAME AMONG THE GOVERNMENT, ENTERPRISE AND THE SOCIETY

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Suppose the proportion of intervention of the government is x, so the proportion of non-intervention is 1-x; the proportion of performance of enterprises is y, so the proportion of non-performance of enterprises is 1-y; the proportion of

supervision of the society is z, so the proportion of non-supervision of enterprises is 1-z.

Suppose under government intervention, the expected benefits and the average benefits are U_{1Y} and $\overline{U}_1$ [12] respectively, there is:

U_{1Y} =yz(-C_1+R_1+G_3+P_1)+y(1-z)(-C_1+R_1+G_3-P_2)
+(1-y)z(-C_1+R_1+D-G_1+P_1)+(1-y)(1-z)(-C_1+R_1+D-G_1-P_2)
$\overline{U}_1$ =xyz(-C_1+R_1+G_3+P_1)+xy(1-z)(-C_1+R_1+G_3-P_2)
+x(1-y)z(-C_1+R_1+D-G_1+P_1)+x(1-y)(1-z)(-C_1+R_1+D-G_1-P_2)
+(1-x)(1-y)z(-S_1-G_1)+(1-x)(1-y)(1-z)(-S_1-G_1-P_2)

Suppose under enterprises performance of social responsibility, the expected benefits and the average benefits are U_{2Y} and $\overline{U}_2$ respectively, there is:

U_{2Y} =xz(-C_2+R_2+R_4+R_5)+x(1-z)(-C_2+R_2+R_4)
+(1-x)z(-C_2+R_2+R_5)+(1-x)(1-z)(-C_2+R_2)
$\overline{U}_2$ =xyz(-C_2+R_2+R_4+R_5)+xy(1-z)(-C_2+R_2+R_4)
+x(1-y)z(-S_2-D-F)+x(1-y)(1-z)(-S_2-D)+(1-x)yz(-C_2+R_2+R_5)
+(1-x)y(1-z)(-C_2+R_2) +(1-x)(1-y)z(-S_2-F)+(1-x)(1-y)(1-z)(-S_2)

Suppose under social supervision, the expected benefits and the average benefits are U_{3Y} and $\overline{U_3}$ respectively, there is:

U_{3Y} =xy(-C_3+R_3+G_4+W_1)+x(1-y)(-C_3+R_3-G_2+W_1)
+(1-x)y(-C_3+R_3+G_4)+(1-x)(1-y)(-C_3+R_3 -W_2)
$\overline{U_3}$ =xyz(-C_3+R_3+G_4+W_1) +x(1-y)z(-C_3+R_3-G_2+W_1)
+ x(1-y)(1-z)(-S_3-G_2+W_1) +(1-x)yz(-C_3+R_3+G_4)
+(1-x)(1-y)z(-C_3+R_3 -W_2)+(1-x)(1-y)(1-z)(-G_2-W_2-S_3)

3.1 Duplicate dynamic equation of government intervention strategy

Construct the duplicate dynamic equation of government intervention strategy as:

$$F(x)=\frac{dx}{dt}=x(U_{1Y}-\overline{U}_1)$$ =x(1-x)[yzP_2+y(G_3-P_2-D-S_1)+zP_1-C_1+R1+D+S_1]

a) When z=[y(P_2+D+S_1-G_3)+G_1-R_1-D-S_1]/(yP_2+P_1), there is $F(x)\equiv 0$, which means all the three are in a stable state.

b) When z≠[y(P_2+D+S_1-G_3)+C_1-R_1-D-S_1]/(yP_2+P_1), make $F(x)=0$, so $x=0$ and $x=1$ are two stable points of x. Calculate the derivative of $F(x)$ [13]:

$$\frac{dF(x)}{dx}$$ =(1-2x)[yzP_2+y(G_3-P_2-D-S_1)+zP_1-C_1+R_1+D+S_1]
= (1-2x) [z(yP_2+P_1)+y(G_3-P_2-D-S_1) -C_1+R_1+D+S_1]

c) When z>[y(P_2+D+S_1-G_3)+C_1-R_1-D-S_1]/(yP_2+P_1), $\left.\frac{dF(x)}{dx}\right|_{x=1}<0$, $\left.\frac{dF(x)}{dx}\right|_{x=0}>0$, so x=1 is the equilibrium point.

d) When z<[y(P_2+D+S_1-G_3)+C_1-R_1-D-S_1]/(yP_2+P_1), $\left.\frac{dF(x)}{dx}\right|_{x=1}>0$, $\left.\frac{dF(x)}{dx}\right|_{x=0}<0$, so x=0 is the equilibrium point. (1)

Based on the abovementioned discussion, we can get the dynamic trend and the stability of the government, as shown in Figure 1.

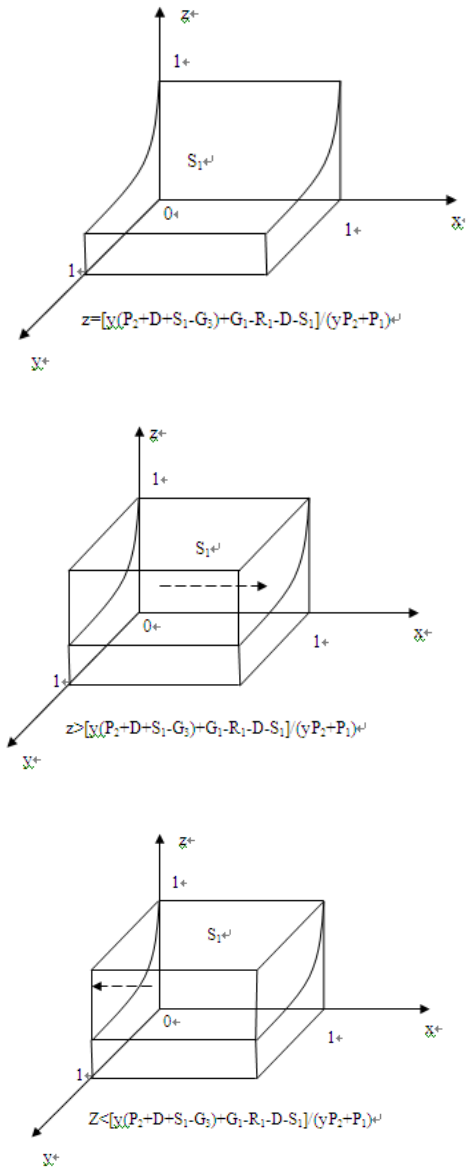


Figure 1. The dynamic trend and the stability of the government

3.2 Typing duplicate dynamic equation of tnterprises' performance of social responsibility strategy

Construct the duplicate dynamic equation of enterprises' performance of social responsibility strate:

$$F(y)=\frac{dy}{dt}=y(U_{2y}-\overline{U_2})$$ =y(1-y)[x(R_4+D)+z(R_5+F)
-C_2+R_2+S_2-M]

a) When $z=[C_2-R_2-S_2+M-x(R_4+D)]/(R_5+F)$, there is $F(y)\equiv 0$, which means all the three are in a stable state.

b) When $z\neq[C_2-R_2-S_2+M-x(R_4+D)]/(R_5+F)$, make $F(y)=0$, so $y=0$ and $y=1$ are two stable points of y. Calculate the derivative of $F(y)$: $\frac{dF(y)}{dy}$ =(1-2y)[x(R4+D)+z(R5+F)-C2+R2+S2-M].

c) When $z>[C_2-R_2-S2+M-x(R_4+D)]/(R_5+F)$, $\left.\frac{dF(y)}{dy}\right|_{y=1}<0$ y=1 is the equilibrium point.

d) When $z<[C_2-R_2-S_2+M-x(R_4+D)]/(R_5+F)$, $\left.\frac{dF(y)}{dy}\right|_{y=0}<0$, y=0 is the equilibrium point.

(2)

Based on the abovementioned discussion, we can get the dynamic trend and the stability of enterprises, as shown in Figure 2.

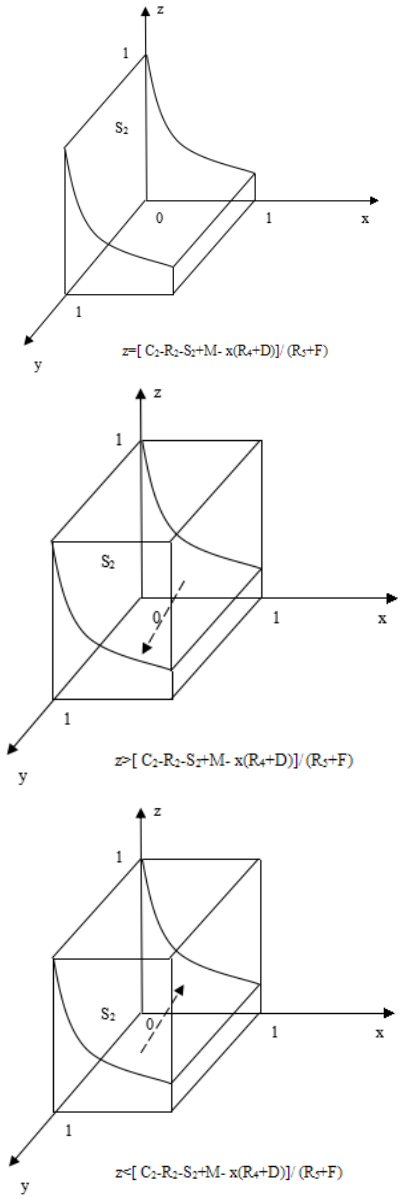


Figure 2. The dynamic trend and the stability of enterprises

3.3 Duplicate dynamic equation of social supervision strategy

Construct the duplicate dynamic equation of the society's supervision strategy:

$$F(z)=\frac{dz}{dt}=z(U_{3y}-\overline{U_3})$$ =z(1-z){y[x(W1+G2)+G4-G2-S3]-xG2-C3+R3+G2+S3}

a) When $y=(xG_2+C_3-R_3-G_2-S_3)/[x(W_1+G_2)+G_4-G_2-S_3]$, there is $F(z)\equiv 0$, which means all the three are in a stable state.

b) When $y\neq(xG_2+C_3-R_3-G_2-S_3)/[x(W_1+G_2)+G_4-G_2-S_3]$, make $F(z)=0$, so $z=0$ and $z=1$ two stable points of z. Calculate the derivative of $F(z)$:

$\frac{dF(z)}{dz}$ = (1-2z) {y[x(W1+G2)+G4-G2-S3]-xG2-C3+R3+G2+S3}

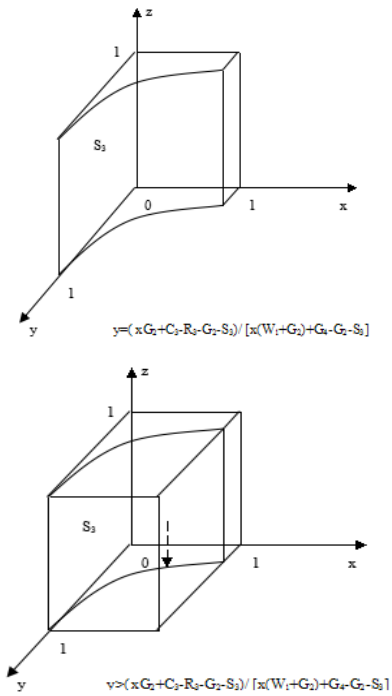
Owing to special characteristics of enterprises, there is $x(W_1+G_2)+G_4-G_2-S_3<0$, so:

c) When $y>(xG_2+C_3-R_3-G_2-S_3)/[x(W_1+G_2)+G_4-G_2-S_3]$, $\left.\frac{dF(z)}{dz}\right|_{z=0}<0$, z=0 is the equilibrium point.

d) When $y<[C_2-R_2-S_2+M-x(R_4+D)]/(R_5+F)$, $\left.\frac{dF(z)}{dz}\right|_{z=1}<0$, z=1 is the equilibrium point.

(3)

Based on the abovementioned discussion, we can get the dynamic trend and the stability of the society, as shown in Figure 3.



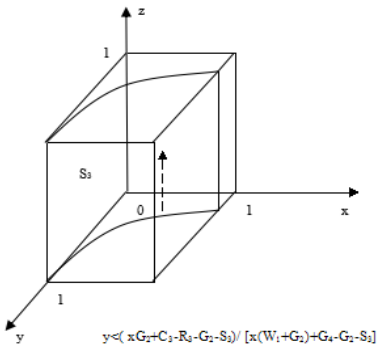


Figure 3. The dynamic trend and the stability of the society

4. EQUATIONS, ANALYSIS OF STABILITY OF THE THREE-PARTY EVOLUTIONARY GAME MODEL

Suppose in Fig.1, curve surface S1 is the bounder from which the cubic is divided into two parts, namely, v1 and v2. In Fig.2, curve surface S2 is the bounder from which the cubic is divided into two parts, namely, v3 and v4. In Fig.3, curve surface S3 is the bounder from which the cubic is divided into two parts, namely, v5 and v6. Analyze three different Game states. The equilibrium state is different with different initial state.

(l) When the initial state falls into the intersection space of v1, v3 and v5, the convergence and balance point is x=1, y=1, z=0. In other word, (intervention, performance, non-supervision) is the inevitable choice of the government, enterprises and the society.

(2) When the initial state falls into the intersection space of v1, v3 and v6 the convergence and balance point is x=1, y=1, z=1. In other word, (intervention, performance, supervision) is the inevitable choice of the government, enterprises and the society.

(3) When the initial state falls into the intersection space of v1, v4 and v5 the convergence and balance point is x=1, y=0, z=0. In other word, (intervention, non-performance, non-supervision) is the inevitable choice of the government, enterprises and the society.

(4) When the initial state falls into the intersection space of v1, v4 and v6 the convergence and balance point is x=1, y=0, z=1. In other word, (intervention, non-performance, supervision) is the inevitable choice of the government, enterprises and the society.

(5) When the initial state falls into the intersection space of v2, v3 and v5 the convergence and balance point is x=0, y=1, z=0. In other word, (non-intervention, performance, non-supervision) is the inevitable choice of the government, enterprises and the society.

(6) When the initial state falls into the intersection space of v2, v3 and v6 the convergence and balance point is x=0, y=1, z=1. In other word, (non-intervention, performance, supervision) is the inevitable choice of the government, enterprises and the society.

(7) When the initial state falls into the intersection space of v2, v4 and v5 the convergence and balance point is x=0, y=0, z=0. In other word, (non-intervention, non-performance, non-supervision) is the inevitable choice of the government, enterprises and the society.

(8) When the initial state falls into the intersection space of v2, v4 and v6 the convergence and balance point is x=0, y=0, z=1. In other word, (non-intervention, non-performance, supervision) is the inevitable choice of the government, enterprises and the society.

As the equilibrium state is resistant to small disturbance and according to the trend of all bodies, we can conclude that x=1, y=1 and z=1 is the ESS of the Game, namely, (intervention, performance, supervision) is the most resistant combination to small disturbance. When the initial state falls into the intersection space of v1, v4 and v5, there is x=1, y=1, z=1. When the initial state falls into other intersection space, as other strategies are not resistant to small disturbance, they would advance to the stable strategy of x=1, y=1, z=1[14].

From Formula 1, as long as the proportion of social supervision exceeds a certain value, the government will stick to the strategy of intervention of corporate social responsibility. If the society chooses the non-supervision strategy, the government will prefer the non-intervention strategy. So, the government is in line with the society in promoting social responsibility. Therefore, two parties should coordinate and play a role together rather than fight for one's own. Otherwise, the corporate social responsibility will be convulsed by non-supervision of the society and non-intervention of the government.

From Formula 2, as long as the proportion of social supervision exceeds a certain value, enterprises will stick to performance of social responsibility. If social supervision is smaller than a certain value, enterprises will prefer non-performance of social responsibility. So, enhancing social supervision will urge enterprises to perform social responsibility.

From Formula 3, when the proportion of enterprises performance of social responsibility is close to 1, social supervision is close to 0. When the proportion of enterprises performance of social responsibility is close to 0, social supervision is close to 1. Even though enterprises have incentives of performance of social responsibility, they would not be anxious to do so. Besides, according to internal and external causes of Marxist theory, internal causes play a more dominant role. So were it not for the government intervention and social supervision, enterprises may not perform social responsibility consciously.

5. CONCLUSIONS

In this Game model, the higher the proportion of government performance intervention, the more likely enterprises will choose the performance of social responsibility. The government's choice of intervention is positively relevant to enterprises' choice of performance of social responsibility. The higher the proportion of the society's performance supervision, the more likely enterprises will choose the performance of social responsibility. The society's choice of supervision is positively relevant to enterprises' choice of performance of social responsibility. In other word, government intervention, performance of corporate social responsibility and social supervision are positively relevant to each other. If the government chooses the intervention strategy, enterprises choose to shoulder corporate social responsibility and the society chooses the supervision strategy, then the three-party model is the best one. With the cooperation of the three, performance of corporate social responsibility is advanced to a higher level.

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