Analysis of Corporate Social Responsibility Based on Evolutionary Game Theory

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Abstract. The paper constructs an evolutionary game model of enterprise and public in the intervention of government, so as to discuss the strategy choice that is whether enterprise fulfills social responsibility or public conduct supervision. Through establishing replicated dynamic equation of the game between enterprise and public, and using Jacobi matrix local stability analysis method to analyze the stability of the replicated dynamic system in local equilibrium, and further explore the dynamic evolution process of game under different incentives intensity of government. The result shows that when the government incentives intensity is large enough, the enterprises that have stronger brand awareness are more willing to fulfill social responsibility; on the contrary, low brand awareness enterprises do not have that strong motivation to fulfill social responsibility. In addition, in a long-term game, public could choose the policy of no supervision, and also indicate that under the condition of asymmetric information, the public have difficult to supervise the enterprise behaviors. According to the above analysis, this paper put forward specific suggestions from the level of government, the public and enterprise.

Introduction

The development of the market economy has been more than 100 years of history, in the process of its development, many social problem have appeared due to business activities of enterprise. Such as environmental pollution, labor rights violations, large numbers of counterfeit goods and so on, which seriously affect the daily life of social members and sustainable development of society. In this situation, the social responsibilities have been proposed.

In the year of 1924, after Oliver Sheldon [1] first proposed the concept of "Corporate social responsibility", academic cycle conducted extensive discussion and research towards corporate social responsibility. So far, the theory of corporate social responsibility is not perfect. This paper attempts to introduce the corporate social responsibility issue to the analysis framework of evolutionary game theory, study the evolutionary process of the game between enterprises and social public under government's intervention, and provide some references for guiding enterprises to actively fulfill its social responsibilities.

Evolutionary Game Theory

Evolutionary game theory is a game theory that based on the assumption of bounded rationality of both sides of the game. In the traditional game theory, it requires participants to be completely rational, but in real economic life, it is difficult to achieve participants' fully rational, which limits the application of game theory in practical problems. In the basis of traditional game theory, evolutionary game theory integrated the thoughts of game theory and Evolutionary biology, which believes participants are bounded rationality and usually continuous improve the decision-making process to reach game equilibrium by trial and error method.

Maynard Smith and Price raised the basic concept of evolutionary game theory in 1973—Evolutionary Stable strategy, that is ESS, which marks the evolutionary game officially become a theory [2]. Evolutionary stable strategy means that if the vast majority of individuals of groups choose evolutionary

stable strategy, the small mutant population is impossible to mutate into this group. Or, under pressure of natural selection, mutation either change strategy to choose evolutionary Stable strategy, or exit the system and disappear in the course of evolution [3].

In order to describe evolutionary stable strategy implementation process, Taylor and Jonker proposed replicator dynamic concept in 1978. Replicator dynamic equation represents the survive rules in the evolution process of game groups, through individual diversity variation mechanisms and preference selection mechanism generating new strategies, comparing with the average efficiency of all strategies, and gradually filter out dominant strategy, that is evolutionary Stable strategy [4].

Evolutionary Game Analysis of Corporate Social Responsibility

Corporate Social Responsibility fulfillment process is a process for enterprises, government and social public interacting with each other and then achieving a balance. Through building evolutionary game model, this paper analyzes the dynamic evolution process of enterprises and social public's long-term game under the intervention of government.

Basic Hypothesis

Corporate Social Responsibility issue conforms to the condition of game theory research, but the balance relationship of enterprise and social public's economic interests is the issue we want to study. For going on the below evolutionary game analysis, the following basic hypothesis is made:

Game subject hypothesis. In the issues of fulfilling enterprise social responsibility, there is existing game subject: enterprise and social public. Game subject has various strategic choices in fulfilling its social responsibilities, for example, the enterprise will face social responsibility problems and make choice between pursuing own economic "windfall profits" and law-abiding, if the enterprise want to survive and develop; social public choose the strategies of supervision or no-supervision, no-supervision more shows lacking of understanding of corporate behavior under asymmetric information; as the state administrative organs, the government must formulate the rules of the game through legislation and regulate the enterprise by law enforcement, if the government willing to achieve both the development of enterprise and the benefits of social.

Profit maximization hypothesis. Game subject is able to make its own profit maximization selections in accord with the goal of profit maximization. All enterprises pursue for economic interests, which can be directly reflected on the financial statements. However, social public care more about external influence brought by enterprise behavior, such influence can be understood as social welfare; the balance of economic development and social stability are more considered in government's intervention to game, such balance can be understood as social interests.

Bounded rationality hypothesis. Game subject can be able to take interaction and influence of behaviors between game players into full consideration when make decisions, and then do rational choices. In the evolution of game, suppose the rational choices of every game subjects is limited, through the method of constant trial and error improving decision-making process to reach game equilibrium, that is the evolutionary stable strategy.

Model and Payoff Matrix

Assuming there is a game between enterprises and social public under the intervention of government. Government is acted as state administrative organs, without considering profits from government's behaviors; we only discuss the changes of the size of government's award and penalty strategy. In the case of government intervention, give a preferential Tariffs T for those enterprises who fulfill its social responsibilities, and impose severe punishment P to those fail to perform social responsibilities.

Enterprises have two different strategy choices. a, the cost of enterprise's fulfilling social responsibilities is C, the brand difference value is B, such difference is showed to be the income increase of enterprise and the cost decrease of advertisement input, which are brought by branding effect of corporate social responsibility. At the same time, the revenue that the positive externalities of enterprise's behavior in fulfilling social responsibility brings to social public is I. b, the loss that the negative externalities of

enterprise's behavior in not fulfilling social responsibility brings to social public is λC (λ is cost effect coefficient, and $\lambda > 1$)

Social publics can choose to supervise or not supervise the behavior of enterprise. The reasons for not supervising are various, one is because of the poor consciousness of social publics, and another is that due to Information asymmetry, publics know little of enterprise's behavior. The supervision cost is S.

Through the description of the above issues, the evolutionary game model of enterprise and the public in the case of government intervention is established. The research object in this model is a "population", due to the bounded rationality, the best strategy in the evolution of the game is constantly 'learning" and continuous improvement of the previous policy until the formation of evolutionary stable strategy (ESS). Where x ($0 \le x \le 1$) indicates the proportion of the social responsibility that enterprises have fulfilled, and y ($0 \le y \le 1$) indicates the proportion of the public select supervision strategy, that ratio can also be understood as a probability.

The payoff matrix of evolutionary game as shown in table 1:

Table1 the game between enterprise and social public

Strategy		Social pubic	
		Without supervision	supervision
Enterprise	No fulfill CSR	$(0, -\lambda C)$	$(-P, -\lambda C-S)$
	Fulfill CSR	$(B+T-C, I)$	$(B+T-C, I-S)$

Replicated Dynamic Equation and Evolutionary Stable Strategy of Evolutionary Game

The average income is E(A1) when the enterprise choose not to fulfilling social responsibility(A1), but when the enterprise choose to fulfilling social responsibility(A2), the average income is E(A2)

$$E(A1) = 0 * (1-y) - P * y = -P * y \tag{1}$$

$$E(A2) = B + T - C \tag{2}$$

The average income that the enterprise chooses not to fulfilling the social responsibility (A1) with the probability of x and to fulfilling the social responsibility (A2) with a 1-x probability is

$$E(\overline{A}) = -P * (1-x)y + x(B+T-C) \tag{3}$$

Similarly, the average income of the strategy that social publics choose to supervise and not to supervise can be concluded

$$E(\overline{B}) = (-\lambda C) * (1-x) + I * x - S * y \tag{4}$$

According to replicated dynamic equation

$$Dx/Dt = x(E(A2) - E(\overline{A})) \tag{5}$$

$$Dy/Dt = y(E(B2) - E(\overline{B})) \tag{6}$$

By putting (1), (2), (3), (4) into (5), (6), it can be drawn

$$Dx/Dt = x(1-x)(P * y + B + T - C) \tag{7}$$

$$Dy/Dt = y(y-1) * S \tag{8}$$

Through the construction of (7), (8) differential equations, we can get the replication dynamic systems with local equilibrium E1 (0, 0), E2 (0, 1), E3 (1, 0), E4 (1, 1).

Friedman [5] proposed that a system of differential equations describe population dynamics, its stability analysis of the partial equilibrium can obtain by analysis of local stability of the system by Jacobi (Jacobi) matrix. The Jacobi matrix of population dynamics system described by (7)(8) is as follows:

$$J = \begin{pmatrix} (1-2x)(Py - C + B + T) & (x - x^2)P \\ 0 & S(2y - 1) \end{pmatrix} \tag{9}$$

So:

$$A_1 = J(0,0) = \begin{pmatrix} B+T-C & 0 \\ 0 & -S \end{pmatrix} \qquad A_2 = J(0,1) = \begin{pmatrix} P+B+T-C & 0 \\ 0 & S \end{pmatrix} \tag{10}$$

$$A_3 = J(1,0) = \begin{pmatrix} C-B-T & 0 \\ 0 & -S \end{pmatrix} \qquad A_4 = J(1,1) = \begin{pmatrix} C-P-B-T & 0 \\ 0 & S \end{pmatrix} \tag{11}$$

Through analysis of the system's positive and negative resistance in the determinant Det(J) and tr(J) of local equilibrium of Jacobi matrix analyzing the evolutionary stable strategy of the replicated dynamic system.

Table 2 The determinant and trace of Jacobi matrix system

Partial equilibrium point	Det(J)	tr(J)
(0,0)	B+T-C-S	S*(C-B-T)
(0,1)	P+B+T+S-C	S*(P+B+T-C)
(1,0)	C-B-T-S	S*(B+T-C)
(1,1)	C+S-P-B-T	S*(C-P-B-T)

Table 3 Local stability analysis of Jacobi matrix

Det(J)Sign	tr(J)Sign	Type judgment of equilibrium point
+	-	Stable point
-	-	Saddle Point
-	+	Saddle Point
+	+	Unstable point

According to table 2 and table 3, make classified discussion to the stability of partial equilibrium under different circumstances.

When government lack incentives efforts, we discuss the following three cases. Case 1: when B+T+P<C, it indicates that the enterprise's brand awareness is low, and the cost of fulfilling social responsibility is high. The stable point of the system is (0,0), saddle point is (0,1), (1,0), the unstable point is (1,1), the system evolution process as shown in figure 1 (a). Through long-term dynamic evolution of game, the enterprise tend to not fulfilling social responsibility, and public could choose not to supervise. Such case is similar to many small and medium enterprises in China, those enterprises have low brand awareness and low economic revenue, which cause them have no strong power to fulfill social responsibility. As for the public, it is hard for them to take effective supervise to enterprise's behavior.

Case 2: when B+T+P>C,B+T<C,T+P<C, it indicates that enterprise have strong brand awareness, and the cost of fulfill social responsibility is respectively high. The stability point is (0, 0), saddle point is (1, 0), the unstable point is (1,1), the system evolution process as shown in figure 1 (b). In this case, the enterprise will choose not to fulfill social responsibility, and the public will choose not to supervise.

Case 3: when B+T>C, T+P<C, it indicates that enterprise have strong brand awareness, and the cost of fulfill social responsibility is respectively high. The stability point is (1, 0), saddle point is (0, 0) and (1, 1), the unstable point is (0,1), the system evolution process as shown in figure 1 (c). This case is the strategic choice of some enterprise with strong brand awareness. Although lack of government' incentives efforts to fulfill corporate social responsibilities, but for reasons of branding in a particular case, the enterprise will choose to fulfill their social responsibilities.

When the government incentive effort is enough, we discuss the following two cases. Case 4: when B+T+P>C, B+T<C, it indicates that enterprise have low brand awareness, and the cost of fulfill social responsibility is also respectively low. The stability point is (0, 0), saddle point is (1, 0) and (1, 1), the unstable point is (0, 1), the system evolution process as shown in figure 1 (b). In the case of large incentive intensity from government, the enterprise with low brand awareness will choose not to fulfill social responsibility, which is because the public cannot full supervise enterprise's behavior, many enterprises hold fluky psychology and make no behavior towards social responsibility.

Case 5: when B+T>C, it indicates that enterprise have strong brand awareness, and the cost of fulfill social responsibility is respectively low. The stability point is (1, 0), saddle point is (0, 0) and (1, 1), the unstable point is (0, 1), the system evolution process as shown in figure 1 (b). This case is happened under a large incentives intensity from the government, the enterprise with strong brand awareness always take such strategy, which is similar to many high-technology, high-added enterprises in developed countries, like America, Japan and so on.
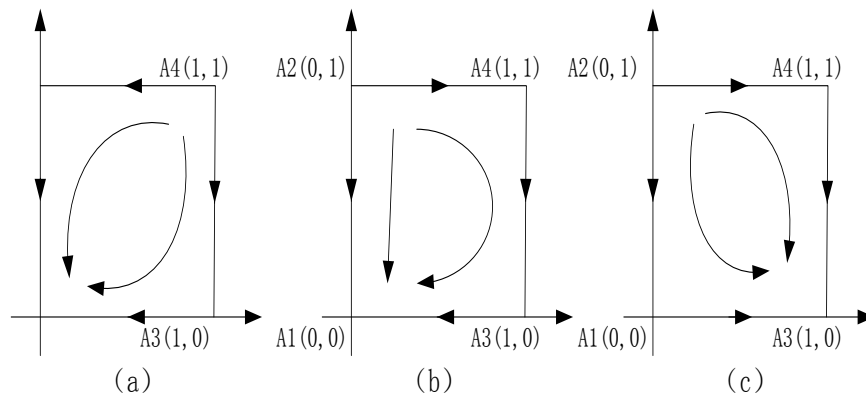

Figure1 the evolution of population dynamics under different circumstances

Conclusion

From the angle of the game, we recognize that corporate social responsibility is not just a matter of individual enterprises, government incentives towards corporate behavior and public supervision will influence the choice of corporate strategy. Based on the discussion of the above five cases, the government rewards and penalties for corporate behavior related to the cost of corporate social responsibility. When the government incentive intensity is large enough, the enterprises with stronger brand awareness is more willing to fulfill their social responsibilities. The corporate with lower brand awareness has never motivated to fulfill their social responsibilities. Meanwhile, in the long-term process of the game, the public would choose the strategy of not supervising, which also shows that in the case of asymmetric information, it is difficult for the public to supervise.

Therefore, in order to promote corporate to fulfill social responsibility, it is necessary to make efforts from three levels of the government, the public and enterprises itself. Firstly, improve the social responsibility legislation, strengthening the rewards and penalties and enforcement of social responsibility behavior, establishing effective information disclosure mechanism. Secondly, strengthen supervision and guidance, raising public awareness of rights. Third, strengthen self-discipline, increase brand awareness.

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