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Green credit, emission reduction and implementary uncertainty

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ABSTRACT

Experimented with market-based mechanisms to supply their traditional command and control mechanisms for environmental protection, green credit has become the most important means. This paper uses the game theory model to study the main body behaviour of China's green credit trading under the uncertain environment. The donor body (government and bank) has implemented information about the political willingness of the enterprise to reduce emissions. The enterprise may be tough or weak on pollution. This paper provides necessary and sufficient conditions for the existence of pooling and separating equilibrium. Perversely, green credit may be invalid, at least in the short run. This is because it provides an incentive for strategic, reputation-building behaviour in the form of excessive emissions.

KEYWORDS

green credit; implementary uncertainty; Bayesian equilibrium.

INTRODUCTION

In the first quarter of 2014, the haze swept through almost the entire northern China. However, the rapid development may be come with the pollution emissions, so environmental problems are necessary to be faced with. The Chinese Government is keen for its traditional command and control mechanisms for environmental protection, but the effect may be not satisfactory, and also brings about some rent-seeking behaviour and other social problems. Since the essence of environmental problem is an economic problem, which means that resolving the environmental problems has to depend on economic means. [1]It becomes an important direction of the new government that relying on the market force method to solve the environmental problems in the future. Financing is the core of the economic and financial resources allocation. At the present, the financing channel of Chinese enterprises mainly derives from banks' credit (TABLE 1), which is followed by the concept of green finance. "Regulations on the implementation of environmental protection policies and regulations to prevent the views of credit risk" are issued jointly by Environmental Protection Administration, People's Bank and China Banking Regulatory Commission in July 2007[2].

TABLE 1 : Domestic social financing scale

Period	Credit loans	Corporate bonds	Equity financing
2009	95942	12367	3350
2010	79451	11063	5786
2011	74715	13658	4377
2012	82035	22498	2508
2013	88917	18021	2219

Data sources: CHINA'S MONETARY policy IMPLEMENTATION REPORT IN THE FOURTH QUARTER OF 2013

The green credit has been carrying out with some results, but there is still a wide gap between expectations. This is because that the objective functions are different among enterprises, banks and government, and both sides of the credit have an overlap of interest. So that the main stakeholders' relationship in the implementation process of green credit policy is very complicated. For instance, some polluting enterprises do not really save energy by using green credit and some implementary uncertainties make the implementation ineffective[3]. Therefore, using the game theory to analyse green credit transactions in this paper is reasonable and it has unique advantages.

MODEL SPECIFICATION

In the implementation process of green credit, this paper will set the government and banks as the lenders and then the enterprise to complete the task of emissions reduction. And the pollution enterprises are the debits, which must provide emissions datum to the lenders and accept their supervision. We will use the classic game model "the north-south framework", which makes use of elastic analysis, static game with complete information and dynamic model with incomplete information, to explain all kinds of body behaviors' characteristics in the green credit implementation [4].

Player:

One player is the lender "Banks and the government "(In the model is the north, Shorted for *N*). Because of the aspiration for better environmental quality, the government has an incentive to implement green credit through bank channels, such as giving interest subsidies, providing guarantee for the enterprise and policy guidance. Banks are not only under the guidance of the government, but also for their own corporate social responsibility to support enterprises' energy saving section role[5]. The other player is polluting companies (In the model is the south, Shorted for *S*), which accepts the green credit and has an obligation to provide the information of emission reducing. However, the emission reduction may cut down its income because, to some extent, a considerable part of the income derives from pollutions. Main players of the two sides still conform to the basic hypothesis by the economist, who are all selfish, namely they are always maximizing their own interests.

Payoff:

We implement effectiveness of specific participants under the strategic combination. In the process of green credit, whether to offer subsidies or providing guarantee, government has certain expenses. However, it also can get good environmental quality and acquire the support from the people. In addition to maintain their own social image promotion, Banks still want to keep their own profit in the process. Even if the rates are the same, using loaning to support the environmental protection of the enterprise, the risk is often higher than the traditional loans, which means the risk premium orthe increasing of the opportunity cost[6]. Getting greener credit will enhance enterprises' capital, thus improving the

efficiency. Nevertheless, there is little motivation to reduce emissions. In a word, the elastic coefficient of *N* is often higher than *S*.

Action:

The north can choose the credit line, indicated by the letter *A*. The south can choose the emissions, indicated by the letter *E* and may be tough or weak to implement.

MODEL ANALYSIS

We assume the North's welfare can be expressed by the utility function $U^n(Y^n, C, q^n)$, where$Y^n$is itspost-transfer income, *C(A)* is its contributions in the form of loaning *A* to the enterprises, and $q^n(E)$ is its environmental quality which depends on the level of enterprises emissions *E*. We assume northern utility is an increasing function of its post-transfer income and environmental quality. Since the Northern post-transfer income is $Y^n = y^n - A$, where $y^n$is its exogenous income, green credit will increase its expense and reduce North's available income, finally reduce the utility.

Contributions are a ''good'' for the North, then $\partial C/\partial A > 0$ and $\partial U^n/\partial C > 0$.The Northern chooses a level of credit volume to maximize its utility, given the level of Southern emissions. We assume $V^n(A, E)$, *E* is strictly concave in *A* for all *E*, so there exists a unique solution to this maximization problem for all *E*. The Northern reaction function is denoted $r^n(E)$. For any given level of emissions, $r^n(E)$ is the level of loaning line that maximizes Northern utility. This reaction function is also shown in Figure 1. It is positively sloped because$\partial^2 U^n/\partial E\partial A > 0$ and the North has a diminishing marginal willingness to pay for environment quality.

We assume the South's welfare can be expressed by the utility function $U^s(Y^s, q^s)$, where $Y^s$is its income and q^s is its environment quality, which depends on its emissions. Southern income is $Y^s = y^s + Q(E) + A$, where $y^s$is its exogenous income and $Q(E)$is its net income from the polluting. We assume that income from this sector is directly related to the level of emissions$\partial Q/\partial E > 0$. Environment quality is a good for the South as well, $\partial Q/\partial E > 0and\partial U^s/\partial q^s > 0$.Like the northern, the Southern reaction function is denoted$r^s(A)$. For any given level of loan, $r^s(A)$ is the level of emissions that maximizes Southern utility. This reaction function is also shown in Figure 1. It is negative sloped because $\partial^2 U^n/\partial E\partial A < 0$, and just opposite to the north.

According to the utility function of both sides, we can draw the two sides elasticity reduction credit volume as *K = δA / δE*. Under the assumption that the North has higher income levels, so for a slight improvement in environment quality, utility upgrade will be very obvious. So that elasticity coefficient greater reaction function in the Figure $r^n(E)$ is steeper than the south. Now suppose that the initial reaction function for the North, $r_1^n(E)$ and the utility of the area is *(D + C)*, implying high pollution and low credit volume. If the north tries to increase the amount of green credit volume the south to reduce emissions, $r^n(E)$will go to the left. Therefore improvingcredit volume makes reducing emissions of the South, and utility area becomes into the *(B + D)*. Since *Kn> Ks* as the model specification *(K* represents elastic), $r^s(A)$ function is inelastic, so the growth rate of credit volume is more than the amount of emission reduction. The increasing effectiveness is of *(C—B)*[7].

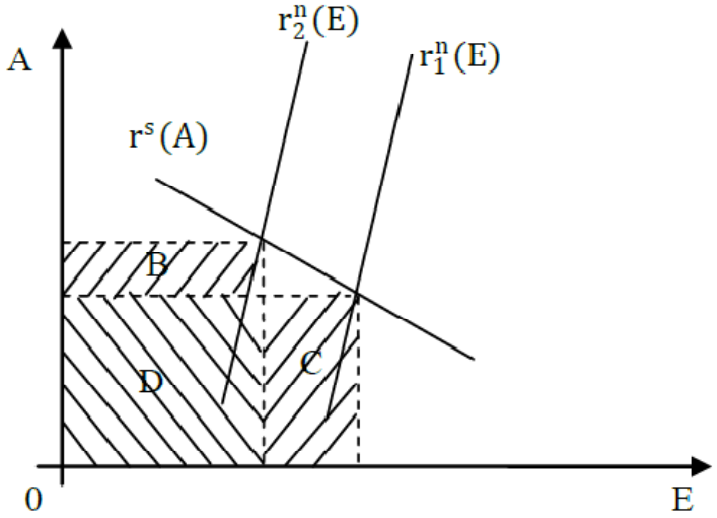

Figure 1: Elastic yield model analysis.

COROLLARY.1 : Due to the north has high income, it is prefer for environment quality than the south. Regardless of the type, in order to reduce the emissions of south, the best response of the north is to increase green credit volume. Because of the response function of the north is steeper than the south, which is similar to the meaning of "Low grain price hurts the farmers ", the north can buy good environment quality and improve its effectiveness through increasing the volume. In a word, the north will choose a high volume with the uncertainty.

After all complete information of the games in real life is few. For simplicity, we assume that, depending upon its political will to abate emissions, the South can be either tough or weak on pollution. We model these two types by assuming there are two possible Southern utility functions, $V_T^S(A,E)$ for the tough type and $V_W^S(A,E)$for the weak type. Each type's problem is to choose a level of emissions to maximize its utility. We assume $V_T^S(A,E)$ and $V_W^S(A,E)$ are each strictly concave in each E for all A, so each type's utility maximization problem has a unique solution for all A. The corresponding Southern best-response reaction functions are denoted $r_T^S(A)$ and $r_W^S(A)$. These reaction functions are depicted in Figure 2 and likes in Figure 1 it is negatively sloped. Finally, to insure the designations weak and tough make sense, we assume that the marginal utility of emissions is greater for the weak type, which means $\partial V_W^S\ (A,E)/\partial E > \partial V_T^S\ (A,E)/\partial E$for all A. It guarantees that the South's best response to any given level of credit volume is to pollute more if it is the weak type, $r_T^S(A) < r_W^S(A)$, and so that the reaction function of the tough type lies below the reaction function of the weak type, which is as also shown in Figure 2.

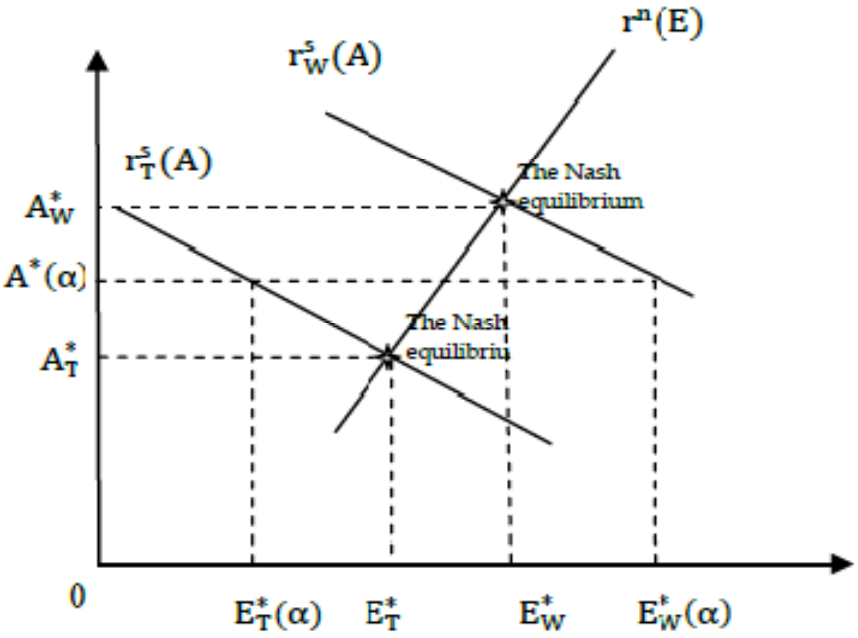

Figure 2: Static bayesian equilibrium.

Take the consideration of the Nash equilibrium which would arise in the two possible games of complete information in which the South's type is known with certainty, these two Nash Equilibriums are also shown in Figure 2. Given the slopes and relative positions of the types of Southern reaction functions and the slope of the Northern reaction function, it is evident that$A_T^* < A^*(\alpha) < A_W^*$ and $E_T^* < E_W^*$. It is that the level of credit volume and emissions are both lower in the certainty game with a Southern country that is tough on emissions. But the final result is often are high Nash equilibrium and of course this is a tragedy.

Now return to the situation where the north does not know whether the South is a weak or tough type. That is, considering the Bayesian game of incomplete information when the credit volume and emissions are chosen, the South has private information regarding to its type. Formally, the strategy of southern type *t=T, W* is a choice of emissions, E_t, from its strategy set, S_t^S, the set of feasible emissions. We assume the strategy sets are $[0-\bar{E}]$, where $\bar{E}$ is just a technological upper bound on the set of feasible emissions. If α denotes the prior probability that the South is a weak type with low implement will to abate emissions, then the North's payoff is its expected utility.

$$N(A,E_T,E_W)=\alpha V^n(A,E_W)+(1-\alpha)V^n(A,E_T)$$

Because the North does not know which type it faces, its optimal choice is a best response to both E_T and E_W. This Bayesian reaction function is denoted $R(E_T,E_W)$.A Bayesian equilibrium is then a triple $(A^*(\alpha),E_T^*(\alpha),E_W^*(\alpha))$such that

$$V_W^S(A^*(\alpha),E_W^*(\alpha)) \geq V_W^S(A^*(\alpha),E),\quad E\in S_W^S$$

$$V_T^S(A^*(\alpha),E_T^*(\alpha)) \geq V_T^S(A^*(\alpha),E),\quad E\in S_T^S$$

$$N(A^*(\alpha),E_T^*(\alpha),E_W^*(\alpha)) \geq N(A,E_T^*(\alpha),E_W^*(\alpha)),\quad A\in S^n$$

COROLLARY.2 : For any kind of $t = T, W, r_t^s$ along with its response function, and increased with the increase of assistance will increase utility. According to the theorem due to$A_T^* < A^*(\alpha) < A_W^*$, can draw due to the unstable factors, makes the Tough types of southern countries have more credit volume and the Weak type of decreased credit volume.

In the reality, it is not only confined in once credit action and emission reduction is not achieved overnight. Generally, it is likely to experience many transactions, namely repeated game[8]. It is no physical contact between stage games and the previous phase will not change the game structure of next phase. All participants can be observed in the previous game. The result of the two participants' payoff will be the summary of all the sub games. The following games will be discussed under the condition of repeated game between the strategy choice and equilibrium analysis. Both sides will use Grim Trigger Strategy, which means if the south chooses the unimplemented, the north will choose the no loaning forever. To be the opposite, if the north chooses the no loaning and the south will choose to stop emission reduction forever.

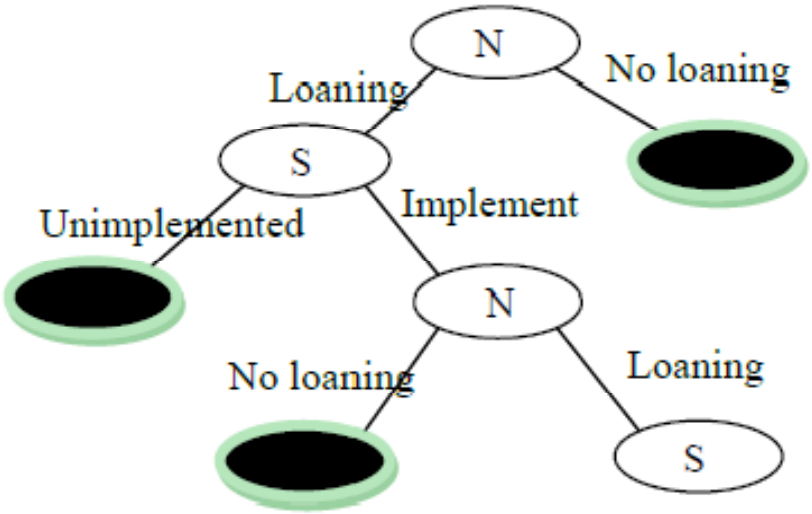

Figure 3: Game tree of infinitely repeated game.

COROLLARY.3 : In the use of infinite times repeat games, because of the action of trigger mechanism, the sum of the utility for each period. Even though the gap between "Implement" and "Unimplemented" is very large, but due to the non-performance after periods income is zero, the utility is $(V_W^s + 0) < \sum V_T^s$, so at this time the game of both sides of the optimal choice for both parties to strictly fulfils own responsibility.

CONCLUSIONS

[1] The temporary credit programs tend to be ineffective, even if a commitment is incredible.

[2] Perhaps the most important lesson of our analysis is that untied green credit can be counter-productive in the presence of recurrent uncertainty (whatever its source) about the willingness of the recipient enterprises to abate emissions[9].

[3] The elegant and the necessary threat is still an important guarantee of the green credit agreement.

[4] Sides of the game should respect each other's interests, programme must be long-term and stable, and namely the infinitely repeated game is a best way to break this paradox.

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