

An Evolutionary Game Analysis of Targeted Poverty Alleviation under the Incentive Mechanism

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Abstract

In this paper, under the incentive mechanism, an evolutionary game model including poor households, enterprises and local governments is established to study the reasons for the difficulties in the process of targeted poverty alleviation in China. Through the participation main body stability analysis found that the government involved in the business tax, loans and other subsidies, get the reputation of the enterprise active participation, active participation of enterprises costs more than passive participation and get the reputation of the local government regulation, government involved in the business tax, loans and other subsidies, local government subsidies on positive working poor, the local government regulation than general regulatory costs is the key to the main impact game strategy choice.

Keywords

Incentive mechanism; Targeted poverty alleviation; Evolutionary game.

1. INTRODUCTION

On October 18, 2017, the report to the 19th National Congress of the Communist Party of China (CPC) called for "mobilizing the strength of the whole Party and the whole society to take targeted measures to alleviate poverty." The No. 1 document of the Central Committee of the Communist Party of China (CPC) 2019 calls for "completing the task of poverty alleviation in an all-round way" and "consolidating and expanding the achievements of poverty alleviation". At the First National Conference on Poverty Alleviation and Development in December 2019, it was proposed to consolidate the achievements made in poverty alleviation, establish sound monitoring and early warning and dynamic assistance mechanisms for poverty alleviation, and prevent those who have been lifted out of poverty and those at the edge of poverty from returning to poverty. With the increase of China's national economic level, people's living standard improves as a whole, but the gap between the rich and the poor also gradually increases. In order to eliminate this phenomenon, General Secretary Xi Jinping has identified targeted poverty alleviation as one of the three major battles to complete the building of a moderately prosperous society in all respects, and governments at all levels throughout the country have been making constant efforts to achieve this goal. According to data released by the National Bureau of Statistics, by the end of 2019, there will be 5.51 million remaining rural poverty-stricken people in China, and 2020 will be the last year of targeted poverty alleviation. It is of great significance to study the reasons for the difficulties in implementing targeted poverty alleviation.

At present, the research on the path of targeted poverty alleviation is relatively comprehensive: Zhang Xia, Wang Bin (2020), Guo Xiangping (2020) and Zhao Ying (2020) studied the mode, predicament and effect evaluation of tourism poverty alleviation against the background of targeted poverty alleviation, and believed that the path of tourism targeted poverty alleviation still has a long way to go in the future; Du Yonghong (2019), Yue Ya, Wang

Guoxian (2018) and Mou Qiuju (2017) studied poverty alleviation through rural e-commerce, and believed that e-commerce entering rural areas is an important means to promote targeted poverty alleviation in rural areas. They also believed that China's rural e-commerce still has problems such as insufficient talents and high logistics cost.

In terms of the game research on targeted poverty alleviation, Zhang Qishan and Yang Chunhui (2019) made a game analysis on the intergenerational transmission of poverty, and proposed that the poverty culture formed in the long term is the fundamental cause of intergenerational transmission. Huang Haitang et al. (2019), on the basis of prospect theory, constructed a game model between the government and enterprises, and determined the reasonable mechanism of poverty alleviation through analysis. Zhang Na et al. (2019) constructed the game process of the government and social organizations in the targeted poverty alleviation under the reward and punishment mechanism, and analyzed the motivation of choosing strategies.

At present, the research on targeted poverty alleviation approaches has been relatively comprehensive, but there are few researches on the reasons for the difficulties in the implementation of these approaches. Game theory is an effective tool to study the contradictions between game players, but there are few literatures on the difficulties in using game theory to study the precise poverty alleviation. Mobilizing all organizations and groups to take part in targeted poverty alleviation is an important force for the success of China's tough fight against poverty. At present, the literature mainly focuses on two-sided game, which makes it difficult to describe the internal mechanism of strategy selection among local governments, enterprises and poverty households. Based on this, this paper, on the basis of previous studies, explores the deep-seated reasons for the difficulties in targeted poverty alleviation in China under the incentive mechanism. So as to put forward more targeted opinions.

2. GAME MODEL CONSTRUCTION

To achieve the goal of building a moderately prosperous society in all respects by 2020, Chinese governments at all levels encourage all social groups to participate in poverty alleviation. So there are three main players in the game: local governments, enterprises and the poor.

2.1. Model Assumptions

First, game players are bounded rationalists. The ultimate goal of local governments, businesses and those who have been lifted out of poverty is to maximize their own profits.

Second, under the incentive mechanism, local governments can choose strict supervision or general supervision; Enterprises participating in poverty alleviation may participate voluntarily or be forced to do so out of policy. In order to change the status, poverty alleviation groups may actively get rid of poverty, or they may rely on government subsidies and passively get rid of poverty in response to the call of the country. Therefore, local governments' strategic space is "strict supervision and general supervision", enterprises' strategic space is "active participation and passive participation", and households' strategic space is "active poverty alleviation and passive poverty alleviation".

Third, compared with the general regulation strategies, local government spending can identify companies such as time, money and poor real motives, under the reward mechanism, when found that companies choose the passive participation, local government will be back to the enterprise has been rewarded, when found poor choice passive out of poverty, will give up to the poor.

Fourthly, the probability of poor households' active poverty alleviation is X, the probability of enterprises' active participation is Y, and the probability of local governments' strict supervision is Z.

2.2. The Meaning of the Main Parameters in the Model

Table 1. Main parameters and symbol description

Parameter	Symbol description
U ₁	The basic income for the poor households to participate in the work of enterprises
U ₂	Additional income from active poverty alleviation by poor households
S ₁	Local government subsidies to the actively working poor
I ₁	The cost of active participation by enterprises
I ₂	The cost of passive participation by enterprises
S ₂	The government subsidizes the taxes and loans of participating enterprises
R ₁	The income that active work of poor households brings to enterprises
F ₁	Reputation earned by active participation of enterprises
C ₁	The cost of strict regulation by local governments
C ₂	The cost of general regulation by local governments
F ₂	Local governments have gained a reputation for strict regulation
K	The impact of poverty reduction on the government's image
a	The depreciation factor of the effect of return to poverty on the poor households
b	The depreciation factor of the impact of the return to poverty on the enterprise

2.3. Game Model

Based on the above assumptions, we can build a game model for local governments, enterprises and poor households. See Table 2.

Table 2. Revenue perception matrix

Agent strategy selection and revenue	Enterprises (Active participation)		Enterprises (Passive participation)	
	Local governments (Strict supervision)	Local governments (General supervision)	Local governments (Strict supervision)	Local governments (General supervision)
	Poor households (Positive out of poverty)	U ₁ +U ₂ +S ₁ -I ₁ +S ₂ +R ₁ +F ₁ -C ₁ +F ₂ -S ₁ -S ₂	U ₁ +U ₂ -I ₁ +S ₂ +R ₁ +F ₁ -C ₂ -S ₂	U ₁ +S ₁ -I ₂ +R ₁ -C ₁ +F ₂ -S ₁ +S ₂
Poor households (Negative out of poverty)	U ₁ -I ₁ +S ₂ +F ₁ -C ₁ +F ₂ -S ₁	U ₁ -I ₁ +S ₂ +F ₁ -C ₂ -S ₂	U ₁ -I ₂ -C ₁ +F ₂ +S ₂	U ₁ -ak -I ₂ +S ₂ -bk -C ₂ -S ₂ -k

2.4. Game Analysis

1. Replication dynamic system for poor households

The income of poor households from positive out of poverty is E11:

$$E_{11} = y[z(U_1 + U_2 + S_1) + (1-z)(U_1 + U_2)] + (1-y)[z(U_1 + S_1) + (1-z)U_1] = U_1 + yU_2 + zS_1$$

The income of poor households from poverty alleviation is E12:

$$E_{12} = U_1 - (1-y)(1-z)aK$$

The average income E1 of the poor households is:

$$E_1 = xE_{11} + (1-x)E_{12}$$

According to the Malthusian equation, the replication dynamic system equation of the poor households can be obtained as follows:

$$G(x) = d(x)/dt = x(E_{11} - E_1) = x(1-x)(E_{11} - E_{12}) = x(1-x)[yE_1 + zS_1 + (1-y)(1-z)aK]$$

To $G(x) = 0$, be able to get $x^*=0, x^*=1, y^* = \frac{-zS_1 - (1-z)aK}{E_1 - (1-z)aK}$

2. Enterprise replication dynamic system

The benefit of enterprises' active participation is E21:

$$E_{21} = x[z(-I_1 + S_2 + R_1 + F_1) + (1-z)(-I_1 + S_2 + R_1 + F_1)] + (1-x)[z(-I_1 + S_2 + F_1) + (1-z)(-I_1 + S_2 + F_1)]$$

$$= -I_1 + S_2 + F_1 + xR_1$$

The benefit of enterprises' passive participation is E22:

$$E_{22} = x[z(-I_2 + R_1) + (1-z)(-I_2 + R_1 + S_2)] + (1-x)[-zI_2 + (1-z)(-I_2 + S_2 - bk)]$$

$$= -I_2 + xR_1 + (1-z)S_2 - b(1-x)(1-z)K$$

The average enterprise income E2 is:

$$E_2 = yE_{21} + (1-y)E_{22}$$

According to the Malthusian equation, the replication dynamic system equation of the enterprise can be obtained as follows:

$$G(y) = d(y)/dt = y(E_{21} - E_2) = y(1-y)[-I_1 + S_2 + F_1 + I_2 - (1-z)S_2 + b(1-x)(1-z)K]$$

To $G(y)=0$, be able to get $y^*=0, y^*=1, z^* = 1 - \frac{I_1 - S_2 - F_1 - I_2}{b(1-x)K - S_2}$

3. Local government replication dynamic system

The income strictly supervised by local governments is E31:

$$E_{31} = y[x(-C_1 + F_2 - S_1 - S_2) + (1-x)(-C_1 + F_2 - S_1)] + (1-y)[x(-C_1 + F_2 - S_1 + S_2) + (1-x)(-C_1 + F_2 + S_2)]$$

$$= -C_1 + F_2 + S_2 - xS_1$$

The income from general supervision of local governments is E32:

$$E_{32} = -C_2 - S_2 - (1-y)(1-x)K$$

The average income of local governments is E3:

$$E_3 = zE_{31} + (1-z)E_{32}$$

According to the Malthusian equation, the replication dynamic system equation of local government can be obtained as follows:

$$G(z) = d(z)/dt = z(E_{31} - E_3) = z(1-z)[-C_1 + F_2 + 2S_2 - xS_1 + C_2 + (1-y)(1-x)K]$$

To $G(z)=0$, be able to get $z^*=0, z^*=1, y^* = 1 - \frac{C_1 - F_2 - 2S_2 + xS_1 - C_2}{(1-x)K}$

2.5. Stability Analysis

According to the method proposed by Friedman (1991), the Jacobian matrix of this system can be obtained as follows:

$$\begin{bmatrix} (1-2x)[yE_1 + zS_1 + (1-y)(1-z)aK] & x(1-x)[E_1 - (1-z)aK] & x(1-x)[S_1 - (1-y)aK] \\ y(1-y)[-b(1-z)K] & (1-2y)[-I_1 + S_2 + F_1 + I_2 - (1-z)S_2 + b(1-x)(1-z)K] & y(1-y)[S_2 - b(1-x)K] \\ z(1-z)[-S_1 - (1-y)K] & -z(1-z)(1-x)K & (1-2z)[-C_1 + F_2 + 2S_2 - xS_1 + C_2 + (1-y)(1-x)K] \end{bmatrix}$$

According to Ritzberger K and Weibull J W (1995) put forward the conclusion, this system need to explore the (0, 0), (0, 1), (0, 0), (0, 1), (1, 1, 0), (1, 1), (0,1,1), (1,1,1) eight points asymptotic stability, the rest are not asymptotically stable state. According to Lyapunov's first rule, if a point is asymptotically stable, the characteristic roots of its corresponding Jacobian matrix should be less than 0. The stability discrimination of each equilibrium point is shown in Table 3.

Table 3. Stability discrimination of each equilibrium point

Equilibrium	Characteristic root 1	symbol	Characteristic root 2	symbol	Characteristic root 3	symbol	state
(0,0,0)	$a*K$	+	$-I_1+F_1+I_2+bK$	unknown	$-C_1+F_2+2S_2+C_2+K$	unknown	Saddle point
(1,0,0)	$-a*K$	-	$-I_1+F_1+I_2$	unknown	$-C_1+F_2+2S_2-S_1+C_2$	unknown	unknown
(0,1,0)	E1	+	$-(-I_1+F_1+I_2+bk)$	unknown	$-C_1+F_2+2S_2+C_2$	unknown	Saddle point
(0,0,1)	S1	+	$-I_1+S_2+F_1+I_2$	unknown	$-(-C_1+F_2+2S_2+C_2+K)$	unknown	Saddle point
(1,1,0)	-E1	-	$-(-I_1+F_1+I_2)$	unknown	$-C_1+F_2+2S_2-S_1+C_2$	unknown	unknown
(1,0,1)	-S1	-	$-I_1+S_2+F_1+I_2$	unknown	$-(-C_1+F_2+2S_2+C_2)$	unknown	unknown
(0,1,1)	E1+S1	+	$-(-I_1+S_2+F_1+I_2)$	unknown	$-(-C_1+F_2+2S_2+C_2)$	unknown	Saddle point
(1,1,1)	$-E_1-S_1$	-	$-(-I_1+S_2+F_1+I_2)$	unknown	$-(-C_1+F_2+2S_2-S_1+C_2)$	unknown	unknown

According to table 3, (0,0,0), (0,1,0), (0,0,1) and (0,1,1) are saddle points. Therefore, in the early stage of targeted poverty alleviation, the game results will evolve to other points. When $S_2 + F_1 > I_1 - I_2$, $F_2 + 2S_2 - S_1 > C_1 - C_2$, (1,1,1) is the stable equilibrium point of the replication dynamic system.

3. CONCLUSION

To sum up, in the process of targeted poverty alleviation, due to the conflicts of interests and information asymmetry among the participants, it is difficult to carry out the process of targeted poverty alleviation smoothly to maximize their own interests. evolutionary game model of poor households, enterprises and local governments tripartite can be seen that the government involved in the business tax, loans and other subsidies, get the reputation of the enterprise active participation, active participation of enterprises costs more than passive participation and get the reputation of the local government regulation, government involved in the business tax, loans and other subsidies, local government subsidies on positive working poor, the local government regulation than general regulatory costs is the key to the main impact game strategy choice.

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