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Evolutionary game analysis of second-hand book recycling based on the digital support platform

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Abstract: *With the progress of digital science in China, the waste of using paper books is becoming more and more serious. And because the recycling mechanism is not perfect, the recycling rate of paper is very low, the annual cost of teaching materials is countless. Based on the era of "Internet +" background, based on the current quality of people's environmental protection consciousness to strengthen, and information life has been integrated into people's lives, using the Internet technology to build digital support platform, entity books recycling, realize wisdom recycling books, can effectively avoid the waste of resources, is conducive to the optimal allocation of resources, save resources, protect the environment. And now the increasing development of recycling technology, not only limited to online or offline recycling, but multi-party operation. Now, digital support platforms have a lot of user information to sell old books, and a variety of information channels. Based on used book recycling, we built a "digital support platform-used book recycling service enterprise" evolution model and joined the discussion influence of government intervention. It studies and analyzes how the methods the government should take to build the smart old book recycling system, and how to strengthen the cooperation between the two sides to put forward the scientific suggestions for the development of the smart old book recycling*

Key words*: smart old book recycling, old book recycling service enterprises, digital support platform, government intervention, and evolutionary game between the two sides*

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I. Introduction

China's second-hand book trading in recent years gradually active, the demand is strong. With the rapid development of China's publishing industry, the update speed of old and new books owned by readers is getting faster and faster, and the whole society has produced a large number of idle books. The repeated reading rate of these books is low, and the processing pressure of old books in families is rising. In the past, the disposal of old books as waste products wasted resources. With the advent of the sharing economy and the popularity of the concept of environmental protection, the second-hand book trade began to be welcomed by the market and developed rapidly, and the capacity of the second-hand book market is getting bigger and bigger. In recent years, the scale of idle goods in China has been steadily climbing at a rate of 30% per year, reaching 500 billion yuan by 2017. At the same time, the scale of online second-hand transaction users in China is also growing rapidly, and the sales of second-hand idle products has become a trend in the future consumption mode, and second-hand books, as standard products, are a very important part of the second-hand market.

on the Internet, and a variety of second-hand book online trading platforms are developing rapidly. With the development of the Internet, online shopping has become more and more important mode of consumption for people. Due to the enhancement of consumption power and the acceleration of product iteration, the market scale of second-hand goods is getting bigger and bigger. Especially the emergence of mobile terminal platforms such as mobile phones, which makes online second-hand transactions convenient and cross-regional. For example, now second-hand trading platforms such as turn, Xianyu, love recycling and so on, more catch fish, micro recycling, panda grid these relying on WeChat small program for second-hand book recycling and sale trading platform is also developing rapidly

Second-hand book trading market in significant development opportunities, but the related theoretical research is far lag behind the development of the market, academia for the mobile Internet era second-hand book network trading platform research slightly inadequate, the traditional second-hand book network trading platform development tepid, emerging second-hand book network trading platform development has just started, also facing the profit model is not clear, the development model of homogeneity

In the United States, most states are responsible for providing teaching materials for college students and graduate students. One textbook can be used for different students for many years. In addition, there are companies specializing in textbook recycling and non-profit organizations engaged in book recycling to recycle, organize, process and recycle textbooks. Recycling is voluntary in the UK, but saving paper and reducing

teaching costs have become a tradition. Meanwhile, in the UK, some companies specialize in selling old textbooks, making them easier to recycle. In conclusion, old books recycling in recent years, has been closely combined with online, and second-hand book industry as a service ecological industry, under the background of Internet +, how to increase the value of the system, second-hand books are not like network, books can be as a data transmission, not as a virtual entity books to achieve similar virtual data transmission, on the premise of digital technology development, multiple interaction symbiosis for path, under the influence of multidimensional complex factors, very difficult. In reality, the problems of self-interested decision motivation and unequal resources of different subjects and fragmented information acquisition constantly breed, which makes the overall system deeply troubled by "dishonest and false sharing of information, irresponsible shirking responsibility, and lack of depth of cooperation", and the path of multi-dimensional integration and interactive symbiosis is relatively tortuous. And evolution game as an important method of research multi-subject multiple elements interactive ecology, based on the "limited rational individual, and continuous learning adjustment" hypothesis, through the deconstruction of stability, to explore multiple subject, dynamic win-win equilibrium method, more close to the reality learning evolution process, is widely used in multi-subject interests, policy analysis, can more comprehensive analysis of the digital situation books recycling service ecological different subject interactive optimization path and the overall system of the optimal state. In addition, how to formulate and implement reasonable policies to help the parties involved in the overall system to trust and fully cooperate, so as to achieve the stable progress of cooperation and symbiosis and win-win results also needs to be deconstructed.

II. Literature review

So this paper tries to build a digital support platform as the core link, digital support platform and the evolution of the game model, through the introduction of government intervention policy, depicting the digital situation, wisdom books recycling ecological participation subject method to choose the dynamic evolution of the process, and discusses the value to create a win-win the optimal path and influencing factors. May marginal contribution lies in: first, embedded service ecosystem concept, with wisdom books recycling service system multiple interests across the boundary of collaborative evolution, dynamic symbiosis and value for the research goal, to carry out the corresponding subject interaction win-win robust path to explore, can more fit reality wisdom books recycling complex dynamic situation. Second, we try to take the digital support platform as the main research object, analyze the impact of the method selection on the ecological evolution of the overall smart old book recycling service, further clarify the core components of the smart old book recycling service system, and consolidate the value logic of the value co-creation of the smart old book recycling ecosystem. Second, the government intervention as the whole system of regulatory factors rather than the game participants, to carry out the evolution of wisdom books recycling game analysis service system, mainly discusses the government policy changes for digital support platform method selection, influence, further analyzes the government intervention method how to guide the overall game system to value create hyperplasia, pareto optimal, for from digital situation to promote wisdom old books recycling service ecological harmonious development, value to provide more operational methods.

III. Conditional assumptions and symbolic instructions.

Hypothesis 1 : In the evolution game of the old book recycling service ecology, all participants are limited rational individuals, taking their own interests as the first decision-making, information asymmetry between each other, but the optimal method can be achieved through continuous learning and evolution, and the government's intervention accelerates the learning evolution process

Hypothesis 2: both digital support platform or old book recycling service enterprises (positive cooperation, negative cooperation). The probability of choosing positive cooperation is x and y, respectively, so the probability of negative cooperation is $1-x,1-y,and0\leq x,y\leq 1$.

Hypothesis 3 : From the perspective of cost, during the game process, the cost of the cooperation between the digital support platform and the old book recycling service enterprises is Cx and Cy respectively. The digital support platform does not need to carry out in-depth integration and matching, modeling and maintenance of enterprise data, but only needs to pay the basic operation cost of simple interaction and docking, which is recorded as C'x. Similarly, the old book recycling service enterprises only need to pay the basic operating costs (mainly covering the basic use costs of the digital support platform), which is recorded as C'y. From the perspective of revenue, in the process of the game, the revenue of the cooperation between the digital support platform and the old book recycling service enterprises are Rx and Ry respectively. After the cooperation between the two parties, aP value (uncertain size) is the additional income value, which is fixed according to the degree of participation. The digital support platform is aP, and the old book recycling service enterprise is (1-a) P

Hypothesis 4 ：From a regulatory point of view, the government can choose both punishment and subsidy. At the same time, the government, as a rational existence of the whole old book recycling ecosystem, can monitor the positive cooperation between the two sides of the game, and give corresponding reasonable rewards and punishments.(The following is temporarily that Sx = Fx, Sy = Fy, and the government's rewards and penalties are directly put into the income of both parties. Currently, the rewards and penalties are 0, and the government monitoring issues will be discussed later)

IV. Model building and prediction

Establish the income matrix of the bilateral evolution game of the digital support platform old book recovery system.

		Old-book recycling service enterprises	
		Actively cooperate（y）	Negative cooperation（1-y）
Digital support platform	Actively cooperate（x）	Rx+aP-Cx+Sx， Ry+(1-a)P-Cy+Sy	Rx+Sx， Ry-Cy-Fy
	Negative cooperation（1-x）	Rx-Cx-Fx， Ry+Sy	Rx-Fx， Ry-Fy

According to the above assumptions and the revenue matrix, the expected returns of the digital support platform x and the used book recycling service enterprise y in the case of positive and negative cooperation, and constitute the average expected return of both parties. The expected and average returns of the "positive cooperation" and "negative cooperation" methods are H11, H12 and H1 respectively, which are calculated as follows:

H11=y(Rx+aP-Cx)+(1-y)(Rx-Cx)=y（aP）+Rx-Cx

H12=y（Rx）+(1-y)（Rx）=Rx

H1=xH11+(1-x)H12=x(yaP-Cx)+Rx

Copy the dynamic equation calculations(The replication dynamic equation is a dynamic differential equation that can be used to describe the number of frequencies or frequencies of a population adopting a particular method.）

Then the dynamic equation of the evolutionary game copying of the probability x of the "positive cooperation" method selected by the numerical support platform is as follows:

FY(x)=dx/dt=x(H11-H1)=x(1-x)(aPy-Cx)

The expected income and average return when the old book recycling service enterprises adopt the "positive cooperation" and "negative cooperation" methods are H21, H22 and H2 respectively, which are calculated as follows:

H21=x(Ry+(1-a)P-Cy+Sy)+(1-x)(Ry-Cy-Fy)=x(1-a)P+Ry-Cy

H22=x（Ry+Sy）+(1-x)（Ry-Fy）=Ry

H2=yH21+(1-y)H22=y(x(1-a)X-Cy)+Ry

The dynamic equation of the probability game of choosing the "cooperation" method is

FX(y)=dy/dt=y(H21-H2)=y(1-y)((1-a)Px-Cy)

A system of replication dynamic equations consisting of replication dynamic equations of both parties, as follows:

FY(x)=dx/dt=x(H11-H1)=x(1-x)(aPy-Cx)

FX(y)=dy/dt=y(H21-H2)=y(1-y)((1-a)Px-Cy)

. Evolutionary Equilibrium Analysis of Cooperative Subject Behavior Game (Based on jacobian Matrix and Determinant)

Then the equations FY (x) =dx / dt = 0 and FX (= y) =dy / dt=0, the five equilibria are C (0,1), B (0,0), C (1,0), D (1,1), E (Cy / (1-a) X, Cx / aP).

The Jacobian matrix is obtained from the replica dynamic equations in the above equation：

$$\begin{bmatrix} F1 & F2 \\ F3 & F4 \end{bmatrix}$$

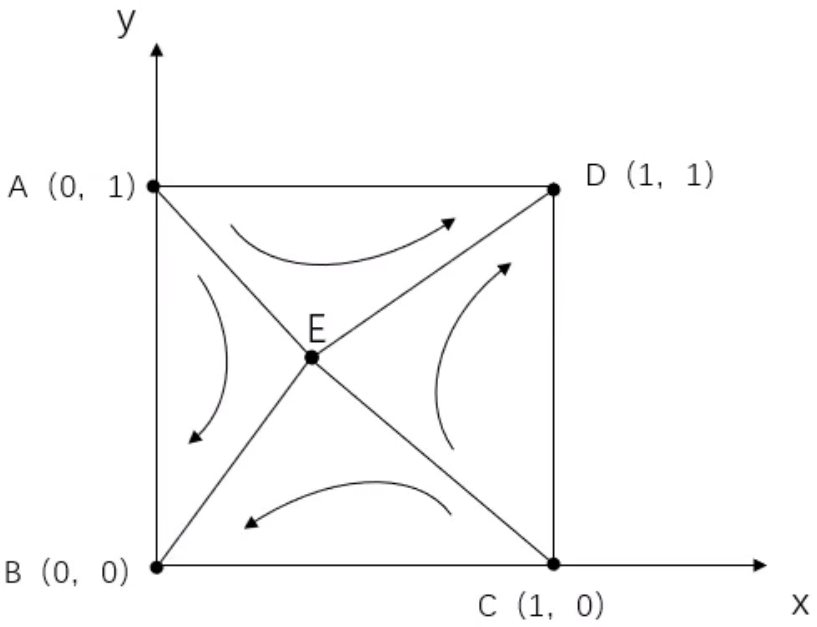
According to the hypothesis, any initial point and its evolved point V= {(x, y) | 0 x 1,0 y 1,} is meaningful, so Cy <(1-a) X, Cx <aP. The determinant of the matrix is dyt (J), and the trace of the matrix is tr (J) . The stability analysis of the five equilibrium points is shown in the table.
Analysis of the evolutionary stability of both parties

equilibrium	dyt(J)	tr(J)
A(0,1)	Cy(aP-Cx)	(aP-Cx)+Cy
B(0,0)	CxCy	- (Cx+Cy)
C(1,0)	Cx((1-a)P-Cy)	((1-a)P-Cy)+Cx
D(1,1)	(Cx-aP)(Cy-(1-a)P)	(Cx-aP)+(Cy-(1-a)P)
E(Cy/(1-a)X,Cx/aP)	[Cy/(1-a)P(Cy/(1-a)P-1)aP] [Cx/aP(Cx/aP-1)(1-a)P]	0

both sides: : det(*A*) >0,*tr*(*A*) <0(Friedman method)
Stability judgment of the equilibrium point

equilibrium	dyt(J)	tr(J)	Equilibriumresult
C(0,1)	+	+	Instability
B(0,0)	+	-	equilibrium
C(1,0)	+	+	Instability
D(1,1)	+	-	equilibrium
Y(Cy/(1-a)P,Cx/aP)	-	undefinite	Saddlepoint

According to the results of evolutionary stability points, equilibrium point B (0,0) and D (1,1) for two equilibrium points, said digital support platform and old books recycling service enterprises at the same time choose "positive" or "at the same time choose" negative cooperation " method, A (0,1) and C (1,0) are two unstable points, said the digital support platform and used recycling service enterprise choose method is different, E (Cy / (1-a) P, Cx / aP) is a saddle point.



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unstable points, said the digital support platform and used recycling service enterprise choose method is different, E (Cy / (1-a) P, Cx / aP) is a saddle point.

Point E is the point that judges the convergence probability of the two replication dynamic curves to point B and D. As shown in the figure, if the starting point of both parties in the game is near point E, subtle changes will change the dynamic evolution results of both parties. The final direction of the participants depends on the comparison of the area S1 of regional ABCM and the area of regional ACDM S2. When S2> S1, the parties tend to actively cooperate results. S2 <S1, then the final method of both sides of the game chooses to be the negative cooperative result. To analyze what factors can affect the stability state of the cooperation method, it is necessary to analyze the parameters affecting the size of S2 area. Digital support platform and old books recycling service enterprises choose the cost of cooperation Cx, Cy and S2 negative correlation, when Cx, Cy increase, S2, namely when the cooperation method, the size of the collaboration cost over a certain range, will make the benefit of less than the cost, prompted both sides to terminate the cooperation, choose the method of negative cooperation.

a and (1-a) are the proportion of the two partners, and the value range of a is [0 1]. When the value of a increases, the corresponding (1-a) will decrease, and when the same value of a decreases, (1-a) will increase, without determining the influence of the area of S2. P is the cooperative benefit of choosing the cooperation method of both parties. A P and (1-A) P are the income distribution of the two parties respectively. When P increases, there will be a positive correlation on the area of S2, so the influence of the numerical change of P on the stability of the method of the two parties can be analyzed.

Based on the above analysis, the method selection of both sides in the evolutionary game will tend to be bilateral cooperation or bilateral negative cooperation. But the influencing factors of the choice method is not only cooperation cost, collaborative benefit and income distribution ratio, also subject to the influence of other factors in the process of the game and constraints, if set other factors into the parameter calculation, copy dynamic equations and evolution game model, its change will also on the evolution of the game results of positive or negative correlation. The different methods will lead the overall system to different stable states; the co-benefits of active cooperation, cooperation costs, government subsidies and negative cooperation, reputation loss, excess profits, etc. will affect the final stable results of the game between the digital support platform and the overall ecosystem.

V. Summary and suggestions

（1）We now discuss the impact of government factors.(Because of the particularity of the government in our country, below briefly discuss the influence of the government, but does not join to the evolutionary game, if join the government can evolve into the tripartite evolution game, and this paper only discuss the evolutionary game, the government influence only limited to a point) from the perspective of the government, the premise is no matter how the government will pay a regulatory cost, if both sides take active measures, the government will receive a good social effect, as the benefits of the government. Regulatory cost of the government if one party take negative measures, the government supervision cost is completely borne by the government, and if the negative party from the positive party get good profits, will lead to negative party continue to negative, positive party negative, E point saddle point, eventually tend to balance point (0,0) in this case, if the government take F> P / a> S or S> P / (1-a)> F. That is, rewards and punishment are in two extremes, resulting in no party choosing negative measures and eventually tending to (1,1). If the government joins one of its own benefits and costs, and achieves the degree of supervision to achieve the optimal benefits of the degree of cooperation, then the saddle point E (Cy / (1-a) P, Cx / aP), that is, the probability of selecting the initial method between the government and private capital and the value of the parameters jointly determine the evolution direction of the system.

（2）For the government and based on digital support platform and old book recycling service enterprises, in order to promote the overall intelligent old book recycling ecology to the evolution and steady state of positive cooperation and value symbiosis, we can try:

Actively linkage between both sides of supply and demand, expand the digital support platform to create profits.one side, The government can start on the supply side, Through policy guidance, technical support, publicity and training, fixed point docking, threshold setting and other ways to help the "multiple linkage", Encourage more high-quality service providers to participate in the smart old book recycling service ecology, Continuously expand the scope of information that can be shared by digital support platforms, And from basic services to advanced research and development and then to application landing, Help them to achieve a more personalized, multi-dimensional, inclusive and friendly service category innovation and technological advancement; on the other hand, The government can start on the demand side, Practice the "sinking route", Connecting with communities and schools, Install various forms of intelligent iot equipment, Multidimensional connection to the user's life, Gathering their real needs, Form personality portraits and user files, And directly

access to the digital support platform, Help the platform to cooperate with suppliers to carry out more accurate matching service design, Realize the traditional homogeneous curing service heterogeneous and personalized transformation.

The government also has the old book recycling service platform and digital support platform should continuously promote both sides to broaden the innovation paradigm and linkage service quality in breadth and depth, so as to improve their co-creation benefits, and consolidate the evolution trend of the overall ecological active cooperation and co-creation. We will accelerate the recycling of smart old books and reduce the cost of cooperation with digital support platforms. On the one hand, the government can continue to optimize the construction of basic digital facilities, promote the popularization of intelligent equipment and digital network, vigorously expand the renovation of smart facilities and equipment, build unified data access, technical specifications, software and hardware standards, etc., continuously optimize the intelligent operator environment, reduce the cost of the digital support platform, strengthen the application and promotion of digital technology and the public welfare publicity of smart old book recycling project, and reduce the publicity cost of the demand side of the platform. In addition, the government can also timely choose capital or technology investment to join the digital support platform, and directly release the financial and technical pressure of the platform. The government should continue to help the digital support platform to reduce input costs from the level of extension and connotation access, and promote the implementation of the overall ecological active cooperation. Set up a reasonable reward and punishment mechanism to regulate the excess profits of the digital support platform.

Through the adoption of the cooperation agreement, the punishment of negative cooperation, the setting of sky-high fines and the implementation of the effective penalty coefficient, can regulate the short-term rent-seeking behavior caused by excess profits, so as to reduce the probability of negative cooperation. On the other side, the parties can attract the digital support platform and increase the probability of choosing positive cooperation.

Both sides can adopt the method of cooperation and agreement through the setting of reasonable reward and punishment mechanism, stimulate the link between the supply and demand side, and help the co-creation of the overall ecology. Strengthen dynamic supervision and improve the reputation pressure of digital support platforms. On the one hand, the Ministry of Finance and the Data Center can integrate the digital support platform into the cooperation trend and service process, such as the service price quality, and regularly publish the reverse and strong reward and punishment method to promote the other party to consolidate the intention of active cooperation; on the other hand, the service evaluation system of media and industry associations to link the supply and demand parties. To provide an important mechanism for service evaluation, opinion collection and complaint feedback. Help both sides to carry out continuous reflection and optimization, and take advantage of the media system disclosure and reputation transmission mechanism, urge both sides to implement the positive behavior of "warm and willing cooperation" in real time, to promote the overall ecological development of smart old book recycling service.

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