



A Study on Antitrust Regulation of Platform Economy Based on Evolutionary Game

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Abstract. This paper analyzes the selection and evolution process of game strategies by constructing an imperfectly rational government, platform enterprises and practitioners as a model of a three-party evolutionary game, and analyzes the conditions for reaching the optimal evolutionary steady state using numerical simulations. The path of China's antitrust transformation in the context of the Internet platform economy is studied, and the influence of different antitrust actors on antitrust behavior is quantitatively evaluated, while the key factors of the path of national policy promotion are pointed out. The results show that in the context of the platform economy, the cost of government and the punishment for corporate violations play a key role in the efficiency of antitrust policy implementation. The advancement of antitrust behavior in the platform economy is more beneficial when the cost of government regulation is smaller and the punishment for violating enterprises is stronger.

Keywords: Off-Platform Economy, Evolutionary Game, Data Simulation, Anti-Monopoly Behavior.

1 Introduction

The rapid development of the platform economy has also given rise to new competition disputes and new issues of antitrust regulation. On the one hand, the highly concentrated market of platform economy inhibits the innovation of SMEs and creates a situation of "winner takes all" ^[1]. On the other hand, the exclusive use of data by platforms strengthens data barriers and hinders data flow, such as the abuse of leverage by platforms to prevent competitors from obtaining data ^[2].

In order to regulate and develop the Internet platform economy, China has continuously introduced anti-monopoly policies ^[3]. On November 10, 2020, the State Administration of Market Supervision issued the "Anti-monopoly Guidelines on the Platform Economy (Draft for Comments)". The Guidelines issued this time clarified that "two-for-one" or other acts with the same effect are restricted transactions in the abuse of dominant market position, providing actionable rules for antitrust enforcers ^[4]. On February 7, 2021, the Anti-monopoly Commission of the State Council officially issued the "Anti-monopoly Commission of the State Council on Antitrust Guidelines in the Platform Economy", supported by theoretical research and empirical investigation,

aiming to protect consumers' interests, guide the healthy development of the platform economy, and focus on building antitrust regulation rules in the platform economy that meet the requirements of high-quality development^[5].

In order to ensure the orderly development of the platform economy, Chinese regulatory and law enforcement agencies have actively carried out the governance of monopoly issues in the platform economy, continuously improving the relevant institutional arrangements and law enforcement mechanisms from legislation to law enforcement, adopting an integrated regulatory mechanism and measures beforehand, during and afterwards, and investigating and dealing with some typical monopoly cases^[6].

2 Literature Review

Domestic scholars have achieved rich results on the antitrust regulation of platform economy. Cong Gu, Ying Liu, Benfu Lu, and Gang Peng summarized the relationship between market structure, economic welfare and platform economy antitrust, and systematically analyzed the antitrust problem from the welfare perspective^[7]. Yang Ming derived a dualistic analytical framework of platform economy antitrust by analyzing the relationship between innovation, firm size and market power from the perspective of competitive structure^[8]. Zeng Xiong proposed countermeasures for the transformation of the platform economy antitrust regulation model based on the consideration of responsive regulation theory^[9]. Jian Li takes the goal of economic efficiency as the starting point to promote the implementation of antitrust law^[10].

Antitrust research on the platform economy has focused on two aspects. First, to analyze the monopoly risk caused by the abuse of the platform economy autonomy algorithm^[11]. Secondly, it summarizes and analyzes the issues of government regulation, legal regulation or competition pattern of the platform economy. Cheng Zengwen believes that the possibility of monopoly risk caused by the abuse of autonomous algorithms is mainly reflected in the abuse of algorithmic power, monopoly of data resources and alienation of platform autonomy^[12]. Jin Shanming summarized various monopolistic behaviors in the platform economy, mainly in the aspects of "choosing one out of two", big data killing, platform blocking and platform self-preference, and systematically analyzed the challenges of the Internet economy to the anti-monopoly law and the reconstruction of the system^[13]. Starting from the three participating subjects of government, platform enterprises and practitioners, this paper studies the evolutionary conditions and processes from the perspective of dynamic development based on the assumption of imperfect rationality of human beings, reflects on the problems of the ideas and models of China's platform economy regulation, and summarizes the shortcomings of the existing anti-monopoly policy of Internet platform economy, puts forward the direction and path of anti-monopoly regulation model.

3 Benchmark Model

3.1 Definition of The Game Subject Subsection Sample

This study assumes that all three parties involved in the game are not fully rational. First, the government is the advocate and supervisor of the anti-monopoly mechanism of the platform. Second, platform enterprises are the main body of the platform economy, and their size and status affect the market position of the enterprises. Third, the practitioners are the demand side of the platform enterprises.

3.2 Description of The Assumptions and Parameters of The Model

Hypothesis 1: The three subjects of the game: government, platform enterprises and practitioners are not fully rational, and they choose the strategy based not on the direct profit and loss of the strategy itself, but on their own perception of the value of the strategy payment.

Hypothesis 2: Information asymmetry. In the platform economy, the information between the participating subjects is incomplete and asymmetric, which is the reason why monopolies need to be governed under the platform economy.

Hypothesis 3: The probability of government regulation is a , the probability of platform enterprises' violation is b , and the probability of practitioners' signing labor contracts is c , satisfying $0 \leq a, b, c \leq 1$. This study assumes that the probabilities of a , b , and c also represent the strength or intensity of government regulation, the strength or intensity of platform enterprises' adopting violation strategies, and the degree of practitioners' willingness to choose to sign labor contracts, respectively.

The policy mix and the corresponding benefit matrix are shown in Table 2, where the parameters are defined and described in Table 1.

Table 1. Definition of parameters.

Symbols	Example
W	Total benefits of government regulation
G	Total cost of government regulation
C_1	Production costs of the enterprise: employee salaries
C_2	Production costs of the enterprise: raw material expenses
L_1	Reasonable earnings for the business
L_2	Illegal proceeds for businesses
K	Fines paid by companies under government supervision
R	Practitioner's salary
S	Salary deductions for practitioners
W	Total benefits of government regulation
G	Total cost of government regulation

Table 2. Game combination and payoff matrix for government, platform companies and practitioners.

Gaming Strategy	Government	Platform companies	Practitioners
Regulation, Violation, Signing	W-G	$L_1+L_2-C_1-C_2-K$	R-S
Regulation, non-compliance, non-signing	W-G	$L_1+L_2-C_2-K$	0
Regulation, no violation, contracting	0	$L_1-C_1-C_2$	R-S
Regulation, no violation, no contract	0	L_1-C_2	0
No regulation, violation, contracting	0	$L_1+L_2-C_1-C_2$	R-S
No regulation, violation, no contract	0	$L_1+L_2-C_2$	0
No regulation, no violation, sign up	0	$L_1-C_1-C_2$	R-S
No regulation, no violation, no contract	0	L_1-C_2	0

4 Game Equilibrium Analysis of Evolving Subjects

4.1 Replication of Dynamic Equations

In the evolutionary game, the game participants need to adjust the size of probability values a, b and c after several games in order to obtain a stable hybrid strategy, the replication dynamic process is the process of dynamic adjustment of probability values of strategy selection by each game subject, the differential equation of probability values a, b and c adjustment is the replication dynamic equation. Suppose E_{11} , E_{12} is the expected return when the government takes the strategy of "regulation" and "no regulation", E_1 is the average expected return of the government, then there are:

$$E_{11}=(W-G)bc+(W-G)b(1-c)=(W-G)b$$

$$E_{12}=0$$

$$E_1=a(Wb-G)$$

Then the evolutionary game replication dynamic equation for the government strategy is:

$$F_1(a)=(E_{11}-E_1)a=(1-a)a(W-G)b$$

Similarly, assuming that E_{21} and E_{22} are the expected returns of the platform firms when they adopt the "violation" and "non-violation" strategies, and E_2 is the average expected return of the platform firms, then we have:

$$E_{21}=L_1+L_2-C_2-Ka-C_1c$$

$$E_{22}=L_1-C_2-C_1c$$

$$E_2=bE_{21}+(1-b)E_{22}$$

$$F_2(b)=(E_{21}-E_2)b=b(1-b)(L_2-Kab)$$

Similarly, assuming that E_{31} and E_{32} are the expected returns when practitioners adopt the "contract" and "no contract" strategies, and E_3 is the average expected return of practitioners, then we have:

$$E_{31} = R - S$$

$$E_{32} = 0$$

$$E_3 = cE_{31} + (1 - c)E_{32}$$

$$F_3(c) = (E_{31} - E_3)c = (1 - c)c(R - S)$$

4.2 Stability Analysis of Evolutionary Game Models

For the tripartite group evolution of government, platform companies and practitioners, it can be analyzed by the replicated dynamic equations of the three, but it is not straightforward to determine which equilibrium point the system will eventually evolve to. In the following, the local stability of the system at these equilibrium points is analyzed qualitatively according to the Jacobi matrix, so that $F_1(a) = 0$, $F_2(b) = 0$, and $F_3(c) = 0$. The replication dynamic equations of the three are associated and assigned to obtain the following set of equations:

$$\begin{cases} (1 - a)a(W - G)b = 0 \\ b(1 - b)(L_2 - Kab) = 0 \\ (1 - c)c(R - S) = 0 \end{cases}$$

Eight equilibria exist in the system when the equilibria are pure strategy combinations satisfying $\begin{cases} (1 - a)a = 0 \\ (1 - b)b = 0 \\ (1 - c)c = 0 \end{cases}$.

From the above three replica dynamic equations, the Jacobi matrix can be found as:

$$J = \begin{bmatrix} F_{11} & F_{12} & F_{13} \\ F_{21} & F_{22} & F_{23} \\ F_{31} & F_{32} & F_{33} \end{bmatrix} = \begin{bmatrix} (Wb - Gb)(1 - 2a) & (W - G)(1 - a)a & 0 \\ 0 & (1 - 2b)L_2 - Ka(2b - 3b^2) & 0 \\ 0 & 0 & (1 - 2c)(R - S) \end{bmatrix}$$

According to Liapunov's discriminant, the equilibrium point is asymptotically stable when all the eigenvalues $\lambda < 0$ of the Jacobi matrix. When all the eigenvalues $\lambda > 0$ of the Jacobi matrix, the equilibrium is an unstable point. The equilibrium point is unstable when the eigenvalues λ of the Jacobi matrix have positive and negative values. The asymptotic stability of the pure-strategy Nash equilibrium point is analyzed as an example in $E_1(0,0,0)$ below, and the stability proofs of other pure-strategy Nash equilibrium points can be obtained similarly.

The Jacobi matrix of the pure strategy Nash equilibrium point $E_1(0,0,0)$ is:

$$J = \begin{bmatrix} 0 & L_2 & 0 \\ 0 & 0 & R - S \end{bmatrix}$$

The eigenvalues at this point are: $\lambda_1=-0$, $\lambda_2=L_2$, $\lambda_3=R-S$. Since $\lambda_3=R-S>0$, this equilibrium is an unstable point. Similarly, the stability analysis of the other seven equilibria can be obtained. The results are shown in table 3.

Table 3. Stability analysis of equilibrium points.

equilibrium point	Eigenvalue	Stability
$E_1(0,0,0)$	0 $L_2>0$ $R-S>0$	Instability point
$E_2(1,0,0)$	0 $L_2>0$ $R-S>0$	Instability point
$E_3(0,1,0)$	When W-G uncertain $-L_2<0$ $R-S>0$	When W - G >0, it is the point of instability. When W - G <0, it is the point of instability.
$E_4(0,0,1)$	0 $L_2>0$ $-(R-S)<0$	Instability point
$E_5(1,1,0)$	When $-(W-G)$ uncertain When $K-L_2$ uncertain $R-S>0$	When $K-L_2<0$ and $W-G>0$, it is asymptotically stable point. All other cases are unstable points
$E_6(0,1,1)$	When W-G uncertain $-L_2<0$ $-(R-S)<0$	when $W-G>0$, it is the point of instability. When $W-G<0$, it is asymptotically stable point.
$E_7(1,0,1)$	0 $L_2>0$ $-(R-S)<$	Instability point
$E_8(1,1,1)$	When $-(W-G)$ uncertain When $K-L_2$ uncertain $-(R-S)<0$	When $K-L_2<0$ and $W>G$, it is asymptotically stable point

4.3 Analysis of Evolutionary Stabilization Strategies

The evolutionary game equilibrium of the behavioral strategies of each participating subject in the three-way replicated dynamic system is influenced by a variety of factors. Now the stability of the equilibrium points in the system is analyzed: First, when $W-G < 0$, $E_6(0, 1, 1)$ is the evolutionary stability point, which indicates that the violation of the platform enterprise is not serious at this time, the market state is good, and the government adopts no regulation strategy. Second, when $K-L_2 < 0$, $E_5(1, 1, 0)$ and $E_8(1, 1, 1)$ are evolutionary stability points, and the platform firms adopt the violation strategy.

4.4 Simulation And Analysis of Data

Based on the three-party replication dynamic equation, we simulate the three-party evolutionary game under the Internet platform economy based on the three-party replication dynamic equation $F_1(a) = (1 - a)a(Wb - Gb)$ with the help of matlab tool, combining the actual operation of the platform economy's enterprises and the network economy. The numerical simulation analyzes the dynamic evolution of the specific behavior of the three parties of the game, and the specific parameters are assigned in Table 4.

Table 4. Model parameter assignment.

Model Parameters	Parameter assignment
W	40
G	10
C ₁	8
C ₂	5
L ₁	50
L ₂	13
K	15
R	3
S	0.01

In order to study the initial influence on the evolutionary path of the three parties, three sets of initial values were set. The results of the first simulation analysis for the three sets of cases are shown below, and the vertical coordinates in the figure indicate the probability of the game parties choosing monopolistic behavior.

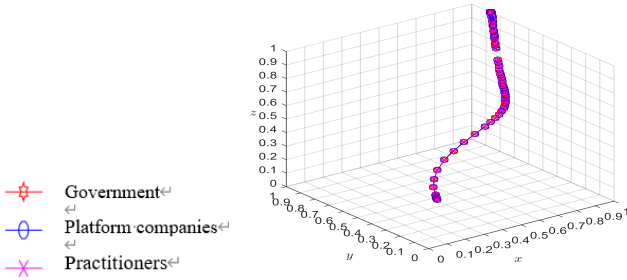


Fig. 1. Initial values: $a=0.2, b=0.2, c=0.2$.

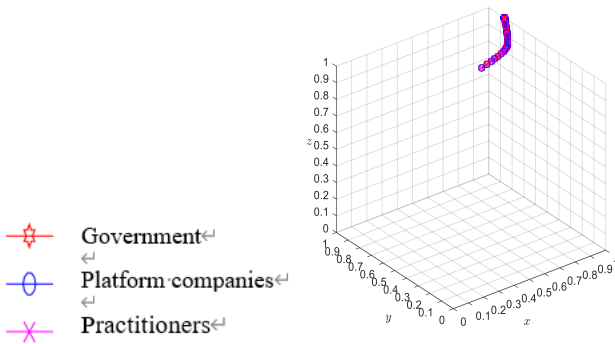


Fig. 2. Initial values: $a=0.8, b=0.8, c=0.8$.

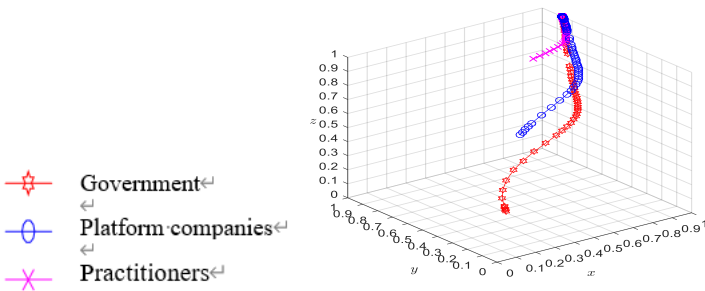


Fig. 3. Initial values: $a=0.2, b=0.5, c=0.8$.

In the above three scenarios, the behavioral strategies of the three subjects of the evolutionary game in Figure 1 and Figure 2 tend to be consistent. The probability of choosing anti-monopoly behavior in Figure 1 is high, while the probability of choosing monopoly behavior in Figure 2 is high, and the probability of choosing anti-monopoly behavior in Figure 3 varies among the three subjects of the game, among which government > platform enterprises > practitioners.

5 Conclusions And Policy Recommendations

5.1 Conclusion

On the one hand, the cost of government regulation has an important impact on the behavioral strategies of platform firms. When the cost of government regulation is increasing, the rate of government regulatory strategy evolution over time becomes slower. The larger the cost of government regulation, the longer the evolution time for platform firms and the government to reach a stable strategy. On the other hand, the stronger the penalties for firms, the more likely the government and platform firms choose aggressive behavioral strategies. This is shown by the faster behavioral evolution rate of the government's choice of regulatory strategy when the punishment increases. The evolutionary stabilization strategy of platform enterprises then changes from a non-violation strategy to a violation strategy, and the larger the penalty, the more likely the enrolled merchants choose a positive behavioral strategy of non-violation^[14].

5.2 Recommendation

First, we should strengthen government regulation, increase government input, and even involve the government in all aspects of production, using the visible hand of the government to play an irreplaceable role^[15]. Enrich the regulatory force, improve the efficiency of regulation, and ensure that the law is really implemented^[16]. The regulatory authorities can also promote market competition by reducing the time of mu inspection and relaxing the market access threshold^[17].

Second, data security and governance are enhanced to optimize corporate governance. Traditional regulation is dominated by mandatory and ex post disciplinary regulation^[18], and self-governance is often neglected. At the government and market levels, the "rights consciousness" of market players should be stimulated, the autonomous status of platforms should be recognized, their sense of main responsibility should be strengthened, and platforms should be urged to enhance self-governance. Constructing an antitrust compliance rating system in China and motivating platforms to carry out self-compliance by means of rewards^[19]. Take technical and management measures to strengthen the security protection of user data, reasonably control data access rights, and avoid data being illegally obtained, modified or leaked^[20]. Establish an antitrust audit system to supervise the implementation of the platform's internal compliance system through a third-party professional organization^[21].

Third, improve the protection system and effectively protect labor rights and interests. In view of the labor characteristics of the platform economy, innovate the criteria for identifying the rights and interests of employees, study and formulate the criteria for effectively protecting the rights and interests of employees, promote the improvement of the processing level of the platform economy, and promote the development of the platform economy^[22].

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