

# Research on Technology Governance of ChatGPT from the Perspective of Tripartite Evolutionary Game

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**Abstract.** With science and technology such as ChatGPT integrating into society, the standardization of technology governance becomes the key to consolidating government power, promoting enterprise development, and enhancing people's livelihood and well-being. Based on a tripartite game model of government, enterprises, and consumers, this paper analyzes their interaction mechanism and evolutionary stability strategy through the dynamic evolutionary game. The results show that there is a stable strategy up against the high risk, that is, enterprises will "use" ChatGPT, consumers will "participate in" ChatGPT, and the government will "advocate" ChatGPT. When the risk is low, two stable strategies exist, in which enterprises still "use" ChatGPT, while the government and consumers have different choices under different strategies. The research results can be used for reference to standardize ChatGPT and promote technical governance.

**Keywords:** ChatGPT; Tripartite Evolutionary Game; Technology Governance.

## 1. Introduction

At the end of 2022, ChatGPT, a chat generative pre-trained transformer, was born. It can continuously learn and understand human language through interactive dialogue with people, which is an important driving force for scientific and technological innovation, industrial upgrading, and productivity improvement. With the development of science and technology as well as its integration with society, social governance is increasingly dependent on emerging science and technology, and society needs to understand, choose, and regulate their application in social governance [1]. Therefore, how to carry out the technology governance of ChatGPT has not only been critical to maintaining market health and stability, but also consolidating government power and enhancing social well-being. Internationally, the United States and other developed countries and regions regard digital technology and artificial intelligence (AI) as key areas of national strategy. For example, the United States has issued a relevant strategy such as *Digital Strategy (2020-2024)*, committed to promoting its digital security and economic prosperity by implementing efficient, effective, and responsible international digital cooperation with allies and partners. In China, the central government mentioned in the *Development Plan of New Generation Artificial Intelligence* that relevant departments should adhere to combining R&D and application with independence and openness, and optimize the layout of AI research. Besides, new AI formats should be actively cultivated and major scientific research projects should be carried out, so as to support the research on basic theories and key AI technologies. Compared with the previous AI technology, the new generation of ChatGPT has obvious advantages, providing an opportunity for the development of politics, economy, society, and other fields. However, due to its new emergence and immaturity, it faces some risks and challenges. Thus, it is vital to study whether the government should advocate ChatGPT, whether enterprises should use ChatGPT, and whether consumers need to participate in ChatGPT or not. Establishing a tripartite evolutionary game model for technology governance of ChatGPT from the perspective of government, enterprises, and consumers, this research studies their dynamic evolution laws and reveals their evolution from the aspect of micro-strategic behavior, so as to provide a reference for the government, enterprises, and consumers to make reasonable decisions.

## 2. Literature Review

The emergence of ChatGPT shows its great potential, which has attracted scholars from many disciplines such as law, mathematics, computer science and technology, etc. Its influence on politics, economy, society, and life is analyzed from different perspectives.

On the one hand, ChatGPT has powerful ability and possibility in many aspects, which is of great significance for further building a comprehensive management agency of AI technology led by the government, coordinated by enterprises, and participated by the public [2]. As for the government, in addition to effectively controlling the digital government scale and helping the decision-making of digital governance, the ChatGPT model also improves its efficiency, reduces its costs, promotes its refinement, and strengthens digital governance supervision [3]. As for enterprises, ChatGPT can enhance production efficiency, promote market value, and realize the positive chain effect in the digital economy [4]. As for the public, ChatGPT integrates human knowledge far more than all search engines, greatly improving the ability and efficiency to obtain information [3].

On the other hand, ChatGPT has some potential risks and challenges. As for the government, the introduction of ChatGPT will challenge its credibility and long-standing organizational structure including business processes and personnel arrangements [5]. As for enterprises, ChatGPT might bring dangers to some traditional industrial enterprises, such as traditional media, customer service, education, etc., reshaping the talent demand of the industry [4]. As for the public, while enjoying efficient access to information, they also face cognitive decline [7], reconstruction of value systems, excessive collection and integration of personal information, and privacy leakage.

According to the literature review, most scholars discuss ChatGPT from a qualitative perspective. Gordijn et al. discussed its advantages and disadvantages through examples from the aspect of whether editors of academic journals need to put forward new policies to deal with the challenges brought by ChatGPT to academic publishing [8]. In addition, Shen and other scholars explored its application duality from specific fields, aiming to apply ChatGPT in medical imaging, clinical decision-making, etc. To sum up, based on the above research gaps, this paper constructs a tripartite evolutionary game model among government, enterprises, and consumers in the technology governance of ChatGPT from a quantitative perspective, so as to provide references for their future strategic choice and development.

## 3. Model Variables and Basic Hypotheses

### 3.1 Model Variables

This paper assumes that the total income of enterprises participating in the technology governance of ChatGPT can be divided into three parts, including the basic income  $P_1$  obtained by using conventional technology (excluding ChatGPT), the income  $Q_1$  obtained by using ChatGPT, and the additional income  $L$  from consumers. The participation cost of enterprises is  $T_1$  and enterprises will be fined  $I$  if they use this technology without governmental advocacy. The total income from consumers participating in ChatGPT governance can be divided into two parts, including the basic income  $P_2$  obtained by using conventional technology (excluding ChatGPT) and the income  $Q_2$  obtained by participating in ChatGPT. The cost of consumers' participation is  $T_2$ . The total income of government participation in the technology governance of ChatGPT includes the basic income  $P_3$  obtained by using conventional technology (excluding ChatGPT), the income  $Q_3$  obtained by participating in ChatGPT, and the additional income  $B_p$  from consumers' support and trust to the government and income  $B_c$  from enterprises' support and trust to the government. The government's participation cost is  $T_3$ , but when consumers and enterprises don't participate or use ChatGPT, the government will pay extra subsidize  $S$  to enterprises. Finally,  $a$  and  $d$  represent the risk coefficient and credibility coefficient respectively, with all variables used in the model can be seen in Table 1.

**Table 1. Model Variables and Definition**

Variable	Definition	Variable	Definition
$P_1$	Basic income obtained by enterprises using conventional technologies	$T_1$	Cost of using ChatGPT in enterprises
$P_2$	Basic income obtained by consumers using conventional technologies	$T_2$	Cost of consumer participation in ChatGPT
$P_3$	Basic income obtained by the government using conventional technology	$T_3$	Cost of government advocating ChatGPT
$Q_1$	Normal income obtained by enterprises using ChatGPT	$B_p$	Consumers' trust in the government
$Q_2$	Normal income of consumers participating in ChatGPT	$B_c$	Trust of enterprises in the government
$Q_3$	Normal income of governmental advocates of using ChatGPT	a	Risk coefficient ( $0 < a < 1$ )
L	The income obtained by enterprises from consumers	d	Credibility coefficient ( $0 < d < 1$ )
I	Government punishment for enterprises (without government advocacy)	S	Government subsidies to enterprises

### 3.2 Basic Hypotheses

Hypothesis 1: Digital technology governance mainly involves three subjects, that is, government, enterprises, and consumers. The emergence of ChatGPT has brought it great potential. However, unreasonable, incorrect, and irregular use will lead to many problems. Thus, this paper takes the three as the research objects to explore whether the government needs to advocate, whether enterprises should use, and whether consumers should participate in the use of ChatGPT.

Hypothesis 2: The following is about the decision strategy of each stakeholder. Specifically speaking, the enterprise has two strategies including {using ChatGPT or not}; consumers have two possible strategies including {participating in ChatGPT or not}; and the government also has two possible strategies including {advocating ChatGPT or not}.

Hypothesis 3: Assuming that all participants rationally master information with incomplete symmetry. In the evolutionary game model, all three parties are in the initial stage, where we do not consider other subjects that may affect the technology governance of Chat GPT.

## 4. Model Construction and Solution

### 4.1 Government Advocates the Use of ChatGPT

#### (1) Expected Income of Enterprises

Enterprises will get basic income  $P_1$  when using conventional technologies (excluding ChatGPT).

The circumstance where enterprises use ChatGPT with consumers' participation is as followed. An enterprise using ChatGPT will get the normal income  $aQ_1$  for its efficiency, personnel, etc., and the income  $L$  from consumers' purchase. Besides, costs  $T_1$  exist, so the expected income of the enterprise at this time is  $P_1 + aQ_1 + L - T_1$ .

The circumstance where enterprises use ChatGPT without consumers' participation is as followed. An enterprise using ChatGPT will get the normal income  $aQ_1$  for its efficiency, personnel, etc. Without consumers' participation, enterprises will lose money, so the government will provide subsidies  $S(S - L < 0)$ . If enterprises use ChatGPT, there must be certain costs  $T_1$ . At this time, the expected income of the enterprise is  $P_1 + aQ_1 + S - T_1$ .

When enterprises do not use ChatGPT with or without consumers' participation, there will be no cost input and income. At this time, the expected income of the enterprise is  $P_1$ .

#### (2) Expected Income of Consumers

Consumers will get basic income  $P_2$  when they participate in other conventional technologies (excluding ChatGPT).

The circumstance where consumers participate in ChatGPT with enterprises' use is as followed. Consumers will get the normal income  $aQ_2$  brought by using it with a certain cost  $T_2$ . At this time, the expected income of consumers is  $P_2 + aQ_2 - T_2$ .

The circumstance where consumers participate in ChatGPT without enterprises' use is as followed. Without enterprises using it, consumers cannot participate in ChatGPT. The expected income of consumers is  $P_2$ .

When consumers do not participate in ChatGPT with or without enterprises' use, there will be no cost input and income. At this time, the expected income of consumers is  $P_2$ .

### (3) Expected Income of the Government

When the government advocates other conventional technologies (excluding ChatGPT), it will get basic income  $P_3$ . When ChatGPT is introduced, the normal income obtained by advocating it is  $aQ_3$  with the basic investment cost  $T_3$ .

The circumstance where consumers participate in ChatGPT with enterprises' use is as followed. The government will additionally get income  $B_p$  from the support and trust of consumers and income  $B_c$  from the support and trust of enterprises respectively. Besides,  $B_p$  and  $B_c$  is limited compared with other income. At this time, the expected income of the government is  $P_3 + aQ_3 + B_p + B_c - T_3$ .

The circumstance where consumers participate in ChatGPT without enterprises' use is as followed. The government will additionally get income  $B_p$  from the support and trust of consumers and income  $dB_c$  from the support and trust of enterprises.  $d$  is the credibility coefficient, which means although enterprises do not use ChatGPT, the government still gets relatively limited income from the support and trust of enterprises because of governmental advocacy. At this time, the expected income of the government is  $P_3 + aQ_3 + B_p + dB_c - T_3$ .

The circumstance where consumers do not participate in ChatGPT with enterprises' use is as followed. The government will additionally get income  $B_c$  from the support and trust of enterprises and income  $dB_p$  from the support and trust of consumers.  $dB_p$  means that when consumers do not participate in it, the government still gets limited income from the support and trust of consumers because of governmental advocacy. In addition, consumers are not involved, the government needs to provide subsidies  $S$  to enterprises. At this time, the expected income of the government is  $P_3 + aQ_3 + dB_p + B_c - T_3 - S$ .

The circumstance where consumers do not participate in ChatGPT without enterprises' use is as followed. Because the government advocates ChatGPT, it still gets extra income  $dB_p$  from the support and trust of consumers and income  $dB_c$  from the support and trust of enterprises. At this time, the expected income of the government is  $P_3 + aQ_3 + dB_p + dB_c - T_3$ .

## 4.2 Government Does Not Advocate the Use of ChatGPT

### (1) Expected Income of Enterprises

Enterprises will get basic income  $P_1$  when using conventional technologies (excluding ChatGPT).

The circumstance where enterprises use ChatGPT with consumers' participation is as followed. Enterprises using it will get the normal income  $(1 - a)Q_1$  for their efficiency, personnel, etc., and income  $L$  from consumers' purchases, although there will be costs  $T_1$ . Without the advocacy of the government, enterprises will be fined  $I$ , far greater than their income. At this time, the expected income of the enterprise is  $P_1 + (1 - a)Q_1 + L - I - T_1$ .

The circumstance where enterprises use ChatGPT without consumers' participation is as followed. Enterprises using it will get the normal income  $(1 - a)Q_1$  for their efficiency, personnel, etc., although there will be costs  $T_1$ . Without the advocacy of the government, enterprises will be fined  $I$ . At this time, the expected income of the enterprise is  $P_1 + (1 - a)Q_1 - I - T_1$ .

The circumstance where enterprises do not use ChatGPT with or without consumers' participation is as followed. There will be no cost input and income and the expected income of the enterprise is  $P_1$ .

### (2) Expected Income of Consumers

Consumers will get basic income  $P_2$  when they participate in other conventional technologies (excluding ChatGPT).

The circumstance where consumers participate in ChatGPT with enterprises' use is as followed. Consumers will get the normal income  $(1 - a)Q_2$  with certain costs  $T_2$ , and the expected income of consumers is  $P_2 + (1 - a)Q_2 - T_2$ .

The circumstance where consumers participate in ChatGPT without enterprises' use is as followed. Without technology provided by enterprises, consumers will neither pay the cost nor benefit. At this time, the expected income of consumers is  $P_2$ .

The circumstance where consumers do not participate in ChatGPT with or without enterprises' use is as followed. Consumers will neither pay costs nor gain benefits and their expected income is  $P_2$ .

**(3) Expected Income of the Government**

The government will get basic income  $P_3$  when advocating other conventional technologies (excluding ChatGPT).

The circumstance where consumers participate in ChatGPT with enterprises' use is as followed. The government will receive fine  $I$  from enterprises without additional income  $B_p$  from the support and trust of consumers and income  $B_c$  from the support and trust of enterprises. Thus, the government's expected income is  $P_3 + I - B_p - B_c$ .

The circumstance where consumers participate in ChatGPT without enterprises' use is as followed. The government will not get income  $B_p$  from the support and trust of consumers and the government's expected income is  $P_3 - B_p$ .

The circumstance where consumers do not participate in ChatGPT with enterprises' use is as followed. The government will not additionally get income  $B_c$  from the support and trust of enterprises, but will get fine  $I$  from enterprises. Thus, the expected income of the government is  $P_3 + I - B_c$ .

The circumstance where consumers do not participate in ChatGPT without enterprises' use is as followed. Since the government does not advocate ChatGPT, it has no other income and its expected income is  $P_3$ .

Based on the above assumptions and different government decisions, the payment matrix for the tripartite evolutionary game among government, enterprise, and consumer is obtained, as shown in Table 2.

**Table 2.** Payment Matrix for Tripartite Evolutionary Game among Government, Enterprise, and Consumer

		Consumer	
		Participation in (Buying) y	Without Participation (Supervision) 1-y
Government Advocacy z	Enterprise's Use x	$P_3 + aQ_3 + B_p + B_c - T_3$	$P_3 + aQ_3 + dB_p + B_c - T_3 - S$
		$P_1 + aQ_1 + L - T_1$	$P_1 + aQ_1 + S - T_1$
		$P_2 + aQ_2 - T_2$	$P_2$
	Without Enterprise's Use 1-x	$P_3 + aQ_3 + B_p + dB_c - T_3$	$P_3 + aQ_3 + dB_p + dB_c - T_3$
$P_1$		$P_1$	
$P_2$		$P_2$	
Without Government Advocacy 1-z	Enterprise Use x	$P_3 + I - B_p - B_c$	$P_3 + I - B_c$
		$P_1 + (1 - a)Q_1 + L - I - T_1$	$P_1 + (1 - a)Q_1 - I - T_1$
		$P_2 + (1 - a)Q_2 - T_2$	$P_2$
	Without Enterprise's Use 1-x	$P_3 - B_p$	$P_3$
		$P_1$	$P_1$
		$P_2$	$P_2$

**4.3 Model Solution**

**4.3.1 Replicator Dynamic Equations**

The expected return function of "using" and "not using" ChatGPT is  $E_x$  and  $E_{1-x}$  respectively, with  $\bar{E}$  as the average return.

The expected income of the enterprise "using" ChatGPT is  $E_x$ .

$$E_x = zy(P_1 + aQ_1 + L - T_1) + z(1 - y)(P_1 + aQ_1 + S - T_1) + y(1 - z)[P_1 + (1 - a)Q_1 + L - T_1 - I] + (1 - z)(1 - y)[P_1 + (1 - a)Q_1 - T_1 - I] \tag{1}$$

The expected income for enterprises “not using” ChatGPT is  $E_{1-x}$ .

$$E_{1-x} = zyP_1 + z(1 - y)P_1 + y(1 - z)P_1 + (1 - z)(1 - y)P_1 \tag{2}$$

The average income of enterprises is  $\bar{E}$ .

$$\bar{E} = xE_x + (1 - x)E_{1-x} \tag{3}$$

Therefore, the replicator dynamic equation of an enterprise is as follows.

$$\frac{dx}{dt} = x(1 - x)[-zyS + z(2aQ_1 - Q_1 + S + I) + yL + (1 - a)Q_1 - T_1 - I] \tag{4}$$

The expected return function of consumers “participating” and “not participating” in ChatGPT is  $C_y$  and  $C_{1-y}$  respectively, with  $\bar{C}$  as the average return.

The expected return of consumers “participating in” ChatGPT is  $C_y$ .

$$C_y = xz(P_2 + aQ_2 - T_2) + z(1 - x)P_2 + x(1 - z)[P_2 + (1 - a)Q_2 - T_2] + (1 - z)(1 - y)P_2 \tag{5}$$

The expected return of consumers “not participating in” ChatGPT is  $C_{1-y}$ .

$$C_{1-y} = xzP_2 + z(1 - x)P_2 + x(1 - z)P_2 + (1 - z)(1 - y)P_2 \tag{6}$$

The average income  $\bar{C}$  of consumers is as follows.

$$\bar{C} = yC_y + (1 - y)C_{1-y} \tag{7}$$

Therefore, the replicator dynamic equation of consumers is as follows.

$$\frac{dy}{dt} = y(1 - y)[xz(2aQ_2 - Q_2) + x(Q_2 - aQ_2 - T_2)] \tag{8}$$

The expected return function of the government “advocating” and “not advocating” ChatGPT is  $O_z$  and  $O_{1-z}$ , respectively, with  $\bar{O}$  as the average return.

The expected income of the government “advocating” ChatGPT is  $O_z$ .

$$O_z = xy(P_3 + aQ_3 + B_p + B_c - T_3) + y(1 - x)(P_3 + aQ_3 + B_p + dB_c - T_3) + x(1 - y)(P_3 + aQ_3 + dB_p + B_c - T_3 - S) + (1 - x)(1 - y)(P_3 + aQ_3 + dB_p + dB_c - T_3) \tag{9}$$

The expected income of the government “not advocating” is  $O_{1-z}$ .

$$O_{1-z} = xy(P_3 + I - B_p - B_c) + y(1 - x)(P_3 - B_p) + x(1 - y)(P_3 + I - B_c) + (1 - x)(1 - y)P_3 \tag{10}$$

The average government income is  $\bar{O}$ .

$$\bar{O} = zO_z + (1 - z)O_{1-z} \tag{11}$$

Therefore, the government’s replicator dynamic equation is as follows.

$$\frac{dz}{dt} = z(1 - z)[x(2B_c - dB_c - S - I) + xyS + y(2B_p - dB_p) + aQ_3 - T_3 + dB_c + dB_p] \tag{12}$$

### 4.3.2 Equilibrium Solution

The game among enterprises, consumers, and government is evolving, that is, their probability of any strategy is time-dependent. According to the stability principle of differential equations, when all dynamic equations are zero, it means that the whole dynamic system will tend to be stable. Obviously, there are eight special equilibrium points in this paper, including  $E_1(0,0,0)$ ,  $E_2(0,0,1)$ ,  $E_3(0,1,0)$ ,  $E_4(0,1,1)$ ,  $E_5(1,1,1)$ ,  $E_6(1,0,0)$ ,  $E_7(1,0,1)$ ,  $E_8(1,1,0)$ . In other words, stakeholders adopt pure strategies at each equilibrium point. The above eight equilibrium points constitute the boundary of the solution domain of the evolutionary game  $\{(x, y, z) | x = 0, 1; y = 0, 1; z = 0, 1\}$ . When the replicator dynamic equations of the three parties are zero simultaneously, there are equilibrium points of mixed strategies  $E_9(x^*, y^*, z^*)$ .  $x^*, y^*, z^*$  are as shown below. If  $0 < x^* < 1, 0 < y^* < 1, 0 < z^* < 1$ , then the equilibrium solution of the mixed strategy lies in the solution domain of the evolutionary game, otherwise, there is no equilibrium solution.

$$x^* = \frac{C(2B_p - dB_p) + D(T_3 - aQ_3 - dB_p - dB_c)}{CS + D(2B_c - dB_c - I - S)}$$

$$y^* = \frac{B[T_1 + L - (1-a)Q_1] - A(2aQ_1 - Q_1 + S + I) - C}{\frac{BL - AS}{D}}$$

$$z^* = \frac{T_2 - (1-a)Q_2}{(2a-1)Q_2} = \frac{A}{B}$$

### 4.3.3 Evolutionary Stability Strategy

Whether the equilibrium point obtained by replicating the dynamic equation is an evolutionary stability strategy needs further verification. Only when the equilibrium point satisfies both strict Nash equilibrium and pure strategy of Nash equilibrium, they are in the state of evolutionary stability.  $E_9$  is a mixed strategy and cannot be an evolutionary stability strategy. Thus, by analyzing the eigenvalues of the Jacobian matrix of the system, the stability of the system at  $E_1 \sim E_8$  is judged. The calculation formula of the Jacobian matrix is as follows.

$$J = \begin{pmatrix} \frac{\alpha F_1}{\alpha x} & \frac{\alpha F_1}{\alpha y} & \frac{\alpha F_1}{\alpha z} \\ \frac{\alpha F_2}{\alpha x} & \frac{\alpha F_2}{\alpha y} & \frac{\alpha F_2}{\alpha z} \\ \frac{\alpha F_3}{\alpha x} & \frac{\alpha F_3}{\alpha y} & \frac{\alpha F_3}{\alpha z} \end{pmatrix} = \begin{pmatrix} F_{11} & F_{12} & F_{13} \\ F_{21} & F_{22} & F_{23} \\ F_{31} & F_{32} & F_{33} \end{pmatrix}$$

Where  $F_{11} = (1 - 2x)[-zyS + z(2aQ_1 - Q_1 + S + I) + yL + (1 - a)Q_1 - I - T_1]$ ,  $F_{12} = x(1 - x)(-zS + L)$ ,  $F_{13} = x(1 - x)[-yS + (2aQ_1 - Q_1 + S + I)]$ ,  $F_{21} = y(1 - y)[z(2aQ_2 - Q_2) + (Q_2 - aQ_2 - T_2)]$ ,  $F_{22} = (1 - 2y)[xz(2aQ_2 - Q_2) + x(Q_2 - aQ_2 - T_2)]$ ,  $F_{23} = xy(1 - y)(2aQ_2 - Q_2)$ ,  $F_{31} = z(1 - z)(2B_c - dB_c - I - S + yS)$ ,  $F_{32} = z(1 - z)(2B_p - dB_p + xS)$ ,  $F_{33} = (1 - 2z)[x(2B_c - dB_c - I - S) + xys + y(2B_p - dB_p) + aQ_3 - T_3 + dB_p + dB_c]$ .

According to  $0 < z^* < 1$ , simplification can be obtained as follows. When  $0 < a < 1/2$ ,  $aQ_2 - T_2 < 0$ ,  $(1 - a)Q_2 - T_2 > 0$ . When  $1/2 < a < 1$ ,  $aQ_2 - T_2 > 0$ ,  $(1 - a)Q_2 - T_2 < 0$ . By the same token, this paper assumes  $0 < a < 1/2$ , and there is  $aQ_1 - T_1 < 0$ ,  $(1 - a)Q_1 - T_1 > 0$ ,  $aQ_3 - T_3 < 0$ ,  $(1 - a)Q_3 - T_3 > 0$ . When  $1/2 < a < 1$ ,  $aQ_1 - T_1 > 0$ ,  $(1 - a)Q_1 - T_1 < 0$ ,  $aQ_3 - T_3 > 0$ ,  $(1 - a)Q_3 - T_3 < 0$ .

As for the equilibrium point  $E_1(0,0,0)$ , the Jacobian matrix  $J_1$  is as follows,  $DetJ = 0$ , which is obviously not a stable point.

$$J_1 = \begin{pmatrix} (1-a)Q_1 - I - T_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & aQ_3 - T_3 + dB_p + dB_c \end{pmatrix}$$

As for the equilibrium point  $E_2(0,0,1)$ , the Jacobian matrix  $J_2$  is as follows,  $DetJ = 0$ , which is obviously not a stable point.

$$J_2 = \begin{pmatrix} aQ_1 + S - T_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -(aQ_3 - T_3 + dB_p + dB_c) \end{pmatrix}$$

As for the equilibrium point  $E_3(0,1,0)$ , the Jacobian matrix  $J_3$  is as follows,  $DetJ = 0$ , which is obviously not a stable point.

$$J_3 = \begin{pmatrix} L + (1-a)Q_1 - I - T_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 2B_p + aQ_3 - T_3 + dB_c \end{pmatrix}$$

As for the equilibrium point  $E_4(0,1,1)$ , the Jacobian matrix  $J_4$  is as follows,  $DetJ = 0$ , which is obviously not a stable point.

$$J_4 = \begin{pmatrix} L + aQ_1 - I - T_1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -(2B_p + aQ_3 - T_3 + dB_c) \end{pmatrix}$$

As for the equilibrium point  $E_5(1,1,1)$ , the Jacobian matrix  $J_5$  is as follows. In  $J_5, DetJ = -(aQ_1 + L - I - T_1)(aQ_2 - T_2)(2B_p - I + aQ_3 - T_3 + 2B_c)$ ,  $TrJ = 2I - aQ_1 - L + T_1 - aQ_2 + T_2 - 2B_p - aQ_3 + T_3 - 2B_c$ . When  $0 < a < 1/2$ ,  $DetJ > 0, TrJ > 0$ ; when  $1/2 < a < 1$ ,  $Det < 0, TrJ > 0$ . Therefore, when  $1/2 < a < 1$ , there is a stable point.

$$J_5 = \begin{pmatrix} -(L + aQ_1 - I - T_1) & 0 & 0 \\ 0 & -(aQ_2 - T_2) & 0 \\ 0 & 0 & -(2B_p - I + aQ_3 - T_3 + 2B_c) \end{pmatrix}$$

As for the equilibrium point  $E_6(1,0,0)$ , the Jacobian matrix  $J_6$  is as follows. In  $J_6, DetJ = -[(1 - a)Q_1 - I - T_1](Q_2 - aQ_2 - T_2)(aQ_3 - I - S - T_3 + 2B_c + dB_p)$ ,  $TrJ = -[(1 - a)Q_1 - T_1] + Q_2 - aQ_2 - T_2 + aQ_3 - S - T_3 + 2B_c + dB_p$ . When  $0 < a < 1/2$ ,  $DetJ < 0, TrJ < 0$ ; when  $1/2 < a < 1$ ,  $Q_3 - T_3 > 0, DetJ > 0, TrJ > 0$ . Therefore, there is no stable point in this case.

$$J_6 = \begin{pmatrix} -[(1 - a)Q_1 - I - T_1] & 0 & 0 \\ 0 & Q_2 - aQ_2 - T_2 & 0 \\ 0 & 0 & aQ_3 - I - S - T_3 + 2B_c + dB_p \end{pmatrix}$$

As for the equilibrium point  $E_7(1,0,1)$ , the Jacobian matrix  $J_7$  is as follows. In  $J_7, DetJ = (aQ_1 + S - T_1)(aQ_2 - T_2)(aQ_3 - I - S - T_3 + 2B_c + dB_p)$ ,  $TrJ = -aQ_1 + T_1 + aQ_2 - T_2 - (aQ_3 - I - T_3 + 2B_c + dB_p)$ . When  $0 < a < 1/2$ ,  $DetJ < 0, TrJ > 0$ . When  $1/2 < a < 1$ ,  $DetJ > 0, TrJ > 0$ . Therefore, when  $0 < a < 1/2$ , there is a stable point.

$$J_7 = \begin{pmatrix} -(aQ_1 + S - T_1) & 0 & 0 \\ 0 & aQ_2 - T_2 & 0 \\ 0 & 0 & -(aQ_3 - I - S - T_3 + 2B_c + dB_p) \end{pmatrix}$$

As for the equilibrium point  $E_8(1,1,0)$ , the Jacobian matrix  $J_8$  is as follows. In  $J_8, DetJ = [L + (1 - a)Q_1 - I - T_1](Q_2 - aQ_2 - T_2)(2B_p - I + aQ_3 - T_3 + 2B_c)$ ,  $TrJ = -[L + (1 - a)Q_1 - T_1] - (Q_2 - aQ_2 - T_2) + 2B_p + aQ_3 - T_3 + 2B_c$ . When  $0 < a < 1/2$ ,  $DetJ > 0, TrJ < 0$ . When  $a > 1/2$ ,  $DetJ < 0, TrJ < 0$ . Therefore, when  $0 < a < 1/2$ , there is a stable point.

$$J_8 = \begin{pmatrix} -[L + (1 - a)Q_1 - I - T_1] & 0 & 0 \\ 0 & -(Q_2 - aQ_2 - T_2) & 0 \\ 0 & 0 & 2B_p - I + aQ_3 - T_3 + 2B_c \end{pmatrix}$$

Based on the above calculation and analysis, when  $1/2 < a < 1$ ,  $E_5(1,1,1)$  is a stable point. Namely, enterprises “use” ChatGPT, consumers “participate in” ChatGPT, and the government “advocates” ChatGPT. When  $0 < a < 1/2$ ,  $E_7(1,0,1)$  and  $E_8(1,1,0)$  are both the equilibrium point, that is, (a.) enterprises “use” ChatGPT, consumers “do not participate in” ChatGPT, and the government “advocates” ChatGPT; (b.) enterprises “use” ChatGPT, consumers “participate in” ChatGPT, and the government “does not advocate” ChatGPT.

## 5. Conclusion

Taking ChatGPT as an example, this paper constructs a dynamic evolutionary game model among government, enterprises, and consumers. From the perspective of the entire technology governance,

this paper obtains several evolutionary stability strategies through the solution of the model. The specific conclusions are as follows.

From the aspect of risk coefficient analysis, when the risk coefficient is  $1/2 < a < 1$ , that is, the risk is high, (1,1,1) is an evolutionary stability strategy, which means enterprises “use” ChatGPT, consumers “participate in” ChatGPT, and governments “advocate” ChatGPT. When the risk coefficient is  $0 < a < 1/2$ , the risk is low, (1,0,1) and (1,1,0) are evolutionary stability strategies, which means (a.) enterprises “use” ChatGPT, consumers “do not participate in” ChatGPT, and governments “advocate” ChatGPT; (b.) enterprises “use” ChatGPT, consumers “participate in” ChatGPT, and governments “do not advocate” ChatGPT. When the risk is high, the economic and social benefits brought by ChatGPT are huge enough, so the government will advocate its use and development, enterprises will devote themselves to maximizing such benefits, and consumers will participate in making profits from it. When the risk is low, as for the strategy (1,0,1), the government realizes that if ChatGPT is reasonably applied, it will greatly benefit society and enterprises with limited and controllable risks. Thus, the government will advocate its use. In order to pursue the maximum benefit with governmental support, enterprises will use ChatGPT. However, as for consumers, consumers may not to participate in it because of insufficient governmental popularization, preferential strength, or high consumption costs. As for the strategy (1,1,0), both enterprises and consumers can avoid greater risks and the losses caused by risks are controllable, thus the government will not invest to supervise and advocate ChatGPT, allowing the market self-regulation and participation of enterprises and consumers.

## References

- [1] Cheng, H. D. & Chen, F. Understanding technological governance in the context of practice. *China Social Science Review*. (2021). No. 03, p. 83-90+159.
- [2] Li, T. & Feng, H. X. Digital governance: Its multi-dimensional perspective, scientific connotation, and basic elements. *Journal of Nanjing University (Philosophy, Humanities, and Social Sciences)*. Vol. 59. (2022). No. 01, p. 70-79+157-158.
- [3] Zhang, X. H. ChatGPT-like artificial intelligence technology embedded in digital governance: value, risk, its prevention and control. *E-government*. (2023). No. 04, p. 45-56.
- [4] Zhao, J. W., Wang, X., Li, D. W., Liu, A. S. & Zhou, H. Y. ChatGPT: Challenges, development, and governance. *Journal of Beijing University of Aeronautics and Astronautics (Social Sciences Edition)*. Vol. 36. (2023). No. 02, p. 188-192.
- [5] Fan, B. Risk identification and governance strategies for ChatGPT. *Academia Bimestris*. (2023). No. 02, p. 58-63.
- [6] Farrokhnia, M., Banihashem, S. K., Noroozi, O. et al. A SWOT analysis of ChatGPT: Implications for educational practice and research. *Innovations in Education and Teaching International*. (2023). p. 1-15.
- [7] Gordijn, B. & Have, H. ChatGPT: evolution or revolution?. *Medicine, Health Care and Philosophy*. (2023). p. 1-2.
- [8] Shen, Y., Heacock, L., Elias, J., Hentel, K. D., Reig, B., Shih, G. & Moy, L. ChatGPT and other large language models are double-edged swords. *Radiology*. Vol. 307. (2023). No. 2, e230163.