

## *Retraction*

# **Retracted: Security Regulation and Enterprise Innovation in Communication Industry**

### **Security and Communication Networks**

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### **References**

- [1] K. Gao and L. Ma, "Security Regulation and Enterprise Innovation in Communication Industry," *Security and Communication Networks*, vol. 2021, Article ID 3307493, 11 pages, 2021.

## Research Article

# Security Regulation and Enterprise Innovation in Communication Industry

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This paper conducted an evolutionary game model of the interaction between the governments and communication enterprises and analyzed the impact of the government's communication security regulation on the innovation decision-making of communication enterprises. The results show that the behavior of the governments depends on the social benefits, rent-seeking benefits, and regulating costs in strict and de security regulations. The communication enterprises' behavior depends on the benefits of innovation and the costs in R&D and rent-seeking. When government subsidies are relatively inadequate, the communication enterprises' strategy under government security regulation swings from not-innovation finally to innovation. The policy implications of this study indicate that appropriate de security regulation by the government will help communication enterprises generate a good atmosphere for innovation, and the appropriate increase in subsidies will be more conducive to driving enterprise innovation.

## 1. Introduction

Digital technologies and applications, such as artificial intelligence, big data, cloud computing, and 5G, are reshaping human work and life. Communication has become one of the fastest developing industries in China, and the development of communication enterprises is an important engine to promote the economic growth in China. In the era of big data, communication technologies are changing rapidly, which triggers new types of data security risks. Moreover, data security issues are getting more and more attention, and digital governance has become a new field of global governance. In order to protect the security of communication data, many governments have begun to intervene in this. In December 2019, The United States issued the "Federal Data Strategy and 2020 Action Plan," which established data as a core goal for strategic resource exploration. In June 2020, Europe released the "EDPS 2020–2024 Strategy," which aims to create a safer, fairer, and

more sustainable digital market. In September 2021, China promulgated the "Data Security Law of the People's Republic of China," which clarified the top-level design of national data security governance. Countries are constantly strengthening communication data security control measures and optimizing the policy environment. The security control measures in the communication industry have greatly protected the rights and interests of users and avoided industry risks.

Data are the key element of digital development, especially the basis of intelligent development of enterprises. But as we all know, innovation is risky. Therefore, security and innovation seem to be opposites, especially in the communication industry, which requires data as a support for innovation. How will the security control measures affect the innovation in the communication industry? Innovation is a significant part to improve the competitive advantage edge of many industries [1]. In addition, at the macro level, scholars agree that innovation is the key to national or

regional economic growth [2], while government policy is an important factor affecting enterprise innovation [3–5]. The government will guide the behavior of enterprises through policies. Among the policy measures, government regulation is the most influential and complicated factor in system level. Government regulation refers to the administrative intervention and economic control implemented by government agencies on social-economic entities to achieve specific economic goals, including incentives and punishments [6–9]. Therefore, for the communication industry, the government's communication security regulation will have an important impact.

In fact, there have been many discussions on the relationship between government regulation and enterprise innovation in academia. The results of the research are mainly divided into two groups: the strict regulation and deregulation. The first group, based on the market failure, proposes that government regulation can effectively solve the problem of market failure, directly optimize the allocation of resources, and gradually improve the welfare level of the whole society [10]. For example, Guo et al. [11] found that government special fund subsidies, tax relief, and other regulatory measures would reduce the innovation costs and innovation risks of enterprises [12, 13]. Property rights management and patent management can effectively protect the monopoly income of innovative products and improve the innovation motivation of enterprises. On the other hand, the de regulation mainly starts from the regulatory capture theory. It argues that regulation is mainly controlled by interest groups and does not have much effect on the output and price of regulated industries. It does not encourage business innovation. Moreover, it puts more emphasis on the regulatory cost of the government and the rent-seeking cost of enterprises [14]. Ezlika et al. [15] pointed out that when the cost of government supervision is too high, the government will tend to the strategy of nonsupervision. The choice of enterprise ecotechnological innovation strategy is affected by government regulation costs, rewards, and punishments. D'amato A [16] found that government regulation would inhibit enterprise innovation. It is not difficult to find that the existing research on the relationship between government regulation and enterprise innovation mainly answers the question of "yes" or "no," that is, whether strict government regulation or deregulation promotes enterprise innovation. Since the government's regulatory behavior is not static, it will evolve according to the innovative behavior of the enterprises. Therefore, when studying the relationship between government regulation and enterprise innovation, compared with the relationship between "yes" and "no," how and when the government regulates is more meaningful. In order to support the development of the communication industry, the Chinese government has issued a series of policies and measures. Therefore, the complex impact of these policies and measures on communication enterprises needs to be further explored.

In addition, reexamining the existing literature on government regulation and enterprise innovation, we found that the existing research on government regulation mainly focuses on environmental regulation [17], salary regulation

[18], and trade regulation [19, 20]. There is a lack of relevant research on security regulation, and there are also few studies on security regulation on communication industry. In the background of the era of big data, the security of the communication industry is not only related to the security of residents' personal information, but also related to the national security at the macro level [21], which should be paid more attention. Furthermore, the security regulation on communication industry is conducive to building a healthy and fair industry development environment and pointing out the direction of the industry's healthy development. However, enterprises in the industry also face the increase of security investment costs, which may squeeze out some corporate innovation investments. Under the government's security regulation, there is a threshold point for the enterprise's security investment, which is related to the enterprise's marketization level, profitability, and other characteristics. Then, how should the government regulate the security of the communication industry, and when should the regulation be conducive to stimulating the innovative behavior of enterprises?

In order to answer this question, this paper constructs an evolutionary game model between government security regulation and enterprise innovation in communication industry. We focus on the analysis of the dynamic process of group evolution and discuss how the group participating in the game can achieve this state. Many scholars have used this method to explain the choice of behavioral strategies between the government and enterprises. For example, Yang et al. [22] and Deng et al. [23] reveal that the innovation ecosystem becomes more stable as the governments' penalty costs and subsidies increase. Wang et al. [24] explored the evolutionary process among three parts, including the governments, firms, and consumers, and analyzed how the participants' strategies influence the equilibrium. Chai et al. [25] modeled the evolutionary process between the governments and two manufacturers and pointed out which factors affect their cooperative choices. Sun et al. [26] built two evolutionary models under two mechanisms, including punishment and subsidy, discussed the evolutionary process of players, and derived the ESS of these models. Xiao et al. [27] explored the evolutionary process among governments, enterprises, and institutions, aiming to get the conditions under which enterprises introduce independent innovation and collaborative innovation with the support of finance.

In the process of repeated games, the government and enterprises constantly adjust their own strategies according to the changes of the other's strategy until a dynamic equilibrium is achieved. Through the evolution analysis between the government's security regulation and the innovation strategy of communication enterprises, this paper attempts to find the key factors that drive the innovation of communication enterprises, to clarify how and when the government should carry out security control. This research will provide a theoretical basis for enterprise innovation and provide decision-making reference for the government on how to strengthen the security control of the communication industry in the era of big data.

Section 2 presents the evolutionary game model of government and communication enterprises. Section 3 presents the equilibrium strategies of government and enterprises in different situations. Section 4 presents the data simulation results. Section 5 presents the research conclusions and policy enlightenment.

## 2. Proposed Model

There are two game groups in this game system: the governments and communication enterprises. The governments have two strategies on enterprise innovation: de security regulation and strict security regulation. The strategy set of the governments is {de security regulation, strict security regulation}. According to previous studies, the strict and de security regulations of the governments have different effects on communication enterprises. The main difference is reflected in the complexity of government processes and the time spent by communication enterprises dealing with the regulations. Specifically, the communication enterprises need to spend longer time to deal with the governments as the government process becomes more complex, indicating that the security regulations adopted by the governments become more stringent. Meanwhile, a strict security regulation means more government intervention, which may lead to more serious corruption. The government officials have the opportunity to carry out “bridge charges” in the process of rent-seeking under strict security regulations, thus increasing capital and time costs of communication enterprises. Strict security regulation mainly includes the innovation subsidy to enterprises who adopt the technology innovation and the penalty to communication enterprises who do not adopt the innovation. De security regulation means that the governments take no measure to interfere in enterprises’ decisions.

Moreover, communication enterprises have two different strategies on innovation. The first one is a strategy where communication enterprises adopt innovation and the second strategy is that communication enterprises adopt no innovation. The strategy set of enterprises is {innovation, not-innovation}. The innovation means that the communication enterprises can obtain additional benefits from innovation and the not-innovation means that the communication enterprises do not take innovation and obtain the basic benefits. Furthermore, if the communication enterprises adopt the not-innovation strategies, their actions are sure to be discovered and fined by the government under the strict security regulation, while this scenario does not take place under de security regulation.

*Assumption 1.* The governments and communication enterprises are limited rational, have certain learning abilities and evolution, and behave independently.

*Assumption 2.* There are two strategies for the governments on innovation. The set of strategies is  $G = \{\text{de security regulation, strict security regulation}\}$ . Among them, the probability that the governments choose de security regulation strategy is  $x$ , and the probability that

the governments choose strict security regulation strategy is  $1 - x$ . Moreover, there are two strategies for communication enterprises on innovation. The set of strategies is  $E = \{\text{innovation, not - innovation}\}$ . The probability of introducing innovation strategy is  $y$ , and the probability of introducing not-innovation is  $1 - y$ . In addition, we assume  $x$  and  $y$  are related to time  $t$  and satisfy  $0 \leq x, y \leq 1$ . After continuous learning, the governments and communication enterprises reach the evolutionary stability strategy (ESS). We use  $x^*$  and  $y^*$  to denote the selection probability of the governments and communication enterprises under ESS.

*Assumption 3.* For the governments, we assume that the costs of the government’s security regulation under de security regulation and strict security regulation are  $C_{gd}$  and  $C_{gs}$  ( $C_{gs} > C_{gd}$ ), respectively; the government adopts incentive policies such as subsidies, tax incentives, procurement, and other specific measures to support enterprise innovation, which requires the government to spend a high cost. When the government formulates and implements regulatory policies, such as punishment, information disclosure, and production restriction, which restrict enterprise behavior, and these behaviors have low cost for the government. The social benefits of the governments under de and strict security regulations are  $S_d$  and  $S_s$ , respectively. We use  $\gamma$  to denote the credibility of the governments under strict security regulation, which increases over time. Moreover, we use  $\delta$  to denote the credibility of the governments under de security regulation, which decreases over time. We assume  $\gamma > \delta$ . The financial subsidy for communication enterprises under strict security regulation is  $F_g$  and the penalty for communication enterprises under de security regulation is  $P_g$ .

*Assumption 4.* For communication enterprises, we assume that the original benefits of enterprises under not-innovation is  $\pi$  and their additional revenue obtained after innovation is  $\Delta\pi$ , which is higher than zero. We use  $C_{ed}$  and  $C_{es}$  to denote the communication enterprises’ operating costs under de and strict security regulation, which satisfy  $C_{es} > C_{ed}$ . The R&D cost of the communication enterprises is  $I_e$ . The rent-seeking cost under strict and de security regulations are  $R_s$  and  $R_d$ , which satisfy  $R_s > R_d$ . Table 1 shows notations and symbols. Table 2 presents payoff matrix between governments and communication enterprises.

Let  $U_G$  and  $U_{\bar{G}}$  denote the governments’ expected earnings of “de security regulation” and “strict security regulation” for governments, which are shown as follows:

$$\begin{aligned} U_G &= y(\delta S_d - C_{gd} + R_d) + (1 - y)(\delta S_d - C_{gd}), \\ U_{\bar{G}} &= y(\gamma S_s - C_{gs} - F_g + R_s) + (1 - y)(\gamma S_s - C_{gs} + P_g). \end{aligned} \quad (1)$$

We use  $\bar{U}_G$  to represent the governments’ average earning:

$$\bar{U}_G = xU_G + (1 - x)U_{\bar{G}}. \quad (2)$$

TABLE 1: Notations and symbols.

Symbols	Definitions
$x$	The probability that the governments choose de security regulation strategy
$y$	The probability that the enterprises introduce innovation strategy
$C_{gi}$	The cost of the government's security regulation under de security regulation and under $i$ security regulation, where $i = d, s$
$S_i$	The social benefits of the governments under $i$ security regulation, where $i = d, s$
$\gamma$	The credibility of the governments under strict security regulation
$\delta$	The credibility of the governments under de security regulation
$F_g$	The financial subsidy for communication enterprises under strict security regulation
$P_g$	The penalty for communication enterprises under de security regulation
$\pi$	The original benefits of communication enterprises under not-innovation
$\Delta\pi$	The enterprises' additional revenue obtained after innovation
$C_{ei}$	The enterprises' operating costs under $i$ security regulation, where $i = d, s$
$I_e$	The R&D cost of the communication enterprises
$R_i$	The rent-seeking cost under $i$ security regulation, where $i = d, s$

TABLE 2: Payoff matrix between governments and communication enterprises.

		Governments	
		De security regulation ( $x$ )	Strict security regulation ( $1 - x$ )
Communication enterprises	Innovation ( $y$ )	$\pi + \Delta\pi - C_{ed} - I_e - R_d, \delta S_d - C_{gd} + R_d$	$\pi + \Delta\pi + F_g - C_{es} - I_e - R_s, \gamma S_s - C_{gs} - F_g + R_s$
	Not-innovation ( $1 - y$ )	$\pi - C_{ed}, \delta S_d - C_{gd}$	$\pi - C_{es} - P_g, \gamma S_s - C_{gs} + P_g$

Let  $U_E$  and  $U_{\bar{E}}$  denote the enterprises' expected earnings of "innovation" and "not-innovation," which are shown as follows:

$$\begin{aligned} U_E &= x(\pi + \Delta\pi - C_{ed} - I_e - R_d) + (1 - x)(\pi + \Delta\pi + F_g - C_{es} - I_e - R_s), \\ U_{\bar{E}} &= x(\pi - C_{ed}) + (1 - x)(\pi - C_{es} - P_g). \end{aligned} \quad (3)$$

We use  $\bar{U}_E$  to denote the average earning of communication enterprises:

$$\bar{U}_E = yU_E + (1 - y)U_{\bar{E}}. \quad (4)$$

Based on the dynamic formulas of evolutionary game, we have the replicator dynamic equation of "de security regulation" adopted by the governments  $F(x)$  and the replicator dynamic equation of "innovation" chosen by communication enterprises  $F(y)$  as follows:

$$\begin{aligned} F(x) &= \frac{dx}{dt} = x(U_G - \bar{U}_G) = x(1 - x)[\delta S_d - C_{gd} + yR_d - \gamma S_s + C_{gs} + yF_g - yR_s - (1 - y)P_g], \\ F(y) &= \frac{dy}{dt} = y(U_E - \bar{U}_E) = y(1 - y)[\Delta\pi - I_e - xR_d + (1 - x)F_g - (1 - x)R_s + (1 - x)P_g]. \end{aligned} \quad (5)$$

The replicator dynamic equations of communication enterprises and governments constitute an evolutionary game replication dynamic system, which is shown in (5).

$$\begin{cases} x(U_G - \bar{U}_G) = x(1 - x)[\delta S_d - C_{gd} + yR_d - \gamma S_s + C_{gs} + yF_g - yR_s - (1 - y)P_g] \\ y(U_E - \bar{U}_E) = y(1 - y)[\Delta\pi - I_e - xR_d + (1 - x)F_g - (1 - x)R_s + (1 - x)P_g] \end{cases}. \quad (6)$$

### 3. Analysis of the Model

In this section, we analyze the destination of the tripartite evolutionary game to obtain the evolutionary stable strategy (ESS). When all the replication dynamic equations are equal to zero, we have the equilibrium points as follows.

**Proposition 1.** *The equilibrium points of the replicator dynamic system are  $(0, 0)$ ,  $(0, 1)$ ,  $(1, 0)$ ,  $(1, 1)$  and  $(x_0, y_0)$ ,*

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} \end{bmatrix} = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \quad (7)$$

$$= \begin{bmatrix} (1-2x)[\delta S_d - C_{gd} + yR_d - \gamma S_s + C_{gs} + yF_g - yR_s - (1-y)P_g] & x(1-x)(R_d + F_g + P_g - R_s) \\ -y(1-y)(R_d + F_g + P_g - R_s) & [\Delta\pi - I_e - xR_d + (1-x)F_g - (1-x)R_s + (1-x)P_g] \end{bmatrix}$$

The equilibrium point is an ESS only when  $\det J = \begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc > 0$  and  $\text{tr} J = a + d < 0$ .

**Proposition 2.** *The evolutionary stable strategies are as follows:*

- (i) When  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$  and  $0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$ , the replicator dynamic system has no ESS.
- (ii) When  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$  and  $\Delta\pi - I_e + F_g - R_s + P_g < 0$ , then  $(0, 0)$  is an ESS. The behavior strategy is (de security regulation, not-innovation).
- (iii) When  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$  and  $\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$ , then  $(1, 1)$  is an ESS. The behavior strategy is (strict security regulation, innovation).
- (iv) When  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$  and  $\Delta\pi - I_e + F_g - R_s + P_g < 0$ , then  $(1, 0)$  is an ESS. The behavior strategy is (strict security regulation, not-innovation).
- (v) When  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$  and  $0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$ , then  $(1, 0)$  is an ESS. The behavior strategy is (strict security regulation, not-innovation).
- (vi) When  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$  and  $\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$ , then  $(1, 1)$  is an ESS. The behavior strategy is (strict security regulation, innovation). Table 3 is local stability analysis between the governments and communication enterprises. Table 4 is local stability analysis between the governments and communication enterprises.

where  $0 \leq x_0 \leq 1, 0 \leq y_0 \leq 1$  and  $x_0 = \Delta\pi - I_e + F_g - R_s + P_g/R_d + F_g + P_g - R_s, y_0 = \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g/R_d + F_g + P_g - R_s$ .

Proposition 1 presents the equilibrium points of the replicator dynamic system. However, the equilibrium points are not necessarily the ESS. Therefore, we need to examine the stability of the equilibrium points by the Jacobian matrix, which is shown as follows:

Table 3 shows that the game equilibrium between the communication enterprises and government is related to ten variables: the government's security regulation cost under  $i$  security regulation, where  $i = d, s$  ( $C_{gi}$ ); the social benefits of the governments under  $i$  security regulation, where  $i = d, s$  ( $S_i$ ); the credibility of the governments under strict security regulation ( $\gamma$ ); the credibility of the governments under de security regulation ( $\delta$ ); the financial subsidy for communication enterprises under strict security regulation ( $F_g$ ); the penalty for communication enterprises under de security regulation ( $P_g$ ); the communication enterprises' additional revenue obtained after innovation ( $\Delta\pi$ ); the communication enterprises' operating costs under  $i$  security regulation, where  $i = d, s$  ( $C_{ei}$ ); the R&D cost of the communication enterprises ( $I_e$ ); and the rent-seeking cost under  $i$  security regulation, where  $i = d, s$  ( $R_i$ ). According to the evolutionary game theory, the equilibrium point of  $\det J > 0$  and  $\text{tr} J < 0$  is the evolutionary stability point ESS of the system. Therefore, the six equilibrium cases are discussed as follows.

**3.1. Situation A.** If  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$ ,  $0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$ , there is no evolutionary stability point in the game. This means that when the sum of the difference between strict and de security regulation in social benefits and the penalty for communication enterprises is higher than the difference between these two regulations in security regulation cost (i.e.,  $\gamma S_s - \delta S_d + P_g > C_{gs} - C_{gd}$ ) and lower than the sum of the difference between these two regulations in rent-seeking benefits, the difference of these two regulations in regulation cost, the penalty, and subsidy for communication enterprises (i.e.,  $\gamma S_s - \delta S_d + P_g < R_d + F_g + P_g - R_s + C_{gs} - C_{gd}$ ), the governments are more inclined to take de security regulation. The sum of the additional benefits, government subsidies, and government

TABLE 3: Local stability analysis between the governments and communication enterprises.

Strategy	$0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$			$0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$			$\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$		
	detJ	trJ	State	detJ	trJ	State	detJ	trJ	State
(0, 0)	-	N	Saddle point	+	-	ESS	-	+	Saddle point
(0, 1)	-	N	Saddle point	+	N	Saddle point	-	-	Saddle point
(1, 0)	-	N	Saddle point	-	N	Saddle point	+	+	Saddle point
(1, 1)	-	N	Saddle point	-	+	Saddle point	+	-	ESS
$(x_0, y_0)$	+	0	Central point	Meaningless					

“+” denotes greater than zero, “-” denotes less than zero, and “N” denotes uncertainty.

TABLE 4: Local stability analysis between the governments and communication enterprises.

Strategy	$0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$			$\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$			$\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$		
	detJ	trJ	State	detJ	trJ	State	detJ	trJ	State
(0, 0)	+	+	Saddle point	-	N	Saddle point	+	+	Saddle point
(0, 1)	-	+	Saddle point	+	+	Saddle point	-	N	Saddle point
(1, 0)	+	-	ESS	+	-	ESS	-	N	Saddle point
(1, 1)	-	-	Saddle point	-	N	Saddle point	+	-	ESS
$(x_0, y_0)$	Meaningless			+	0	Central point	+	0	Central point

“+” denotes greater than zero, “-” denotes less than zero, and “N” denotes uncertainty.

finances obtained by the communications company is greater than the sum of the innovation costs it paid and rent-seeking costs under strict security regulation; the additional benefits obtained by the company are less than the innovation costs it paid and the de security regulation and the sum of rent-seeking costs (i.e.:  $I_e + R_s < \Delta\pi + F_g + P_g$ ,  $\Delta\pi + F_g + P_g < R_d + F_g + P_g + I_e$ ). In this situation, entrepreneurs will not have any strategic stable choices.

**3.2. Situation B.** If  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$  and  $\Delta\pi - I_e + F_g - R_s + P_g < 0$ , (0,0) is the ESS. This means that when the sum of the difference between strict and de security regulation in social benefits and the penalty for communication enterprises is higher than the difference between these two regulations in security regulation cost (i.e.,  $\gamma S_s - \delta S_d + P_g > C_{gs} - C_{gd}$ ) and lower than the sum of the difference between these two regulations in rent-seeking benefits, the difference of these two regulations in regulation cost, the penalty, and subsidy for communication enterprises (i.e.,  $\gamma S_s - \delta S_d + P_g < R_d + F_g + P_g - R_s + C_{gs} - C_{gd}$ ), the governments are more inclined to take de security regulation. When the sum of the additional profit from innovation, subsidy from the government, and penalty to the government is lower than the costs of R&D and rent-seeking, communication enterprises are unwilling to implement innovation. This represents the worst scenario, and the way to solve this is to find a third-party to regulate the actions of the government and communication enterprises to reduce the rent-seeking costs.

**3.3. Situation C.** If  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$ ,  $\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$ , the game equilibrium point (1,1) is the evolutionary

stability point. If  $0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < R_d + F_g + P_g - R_s$  and  $\Delta\pi - I_e + F_g - R_s + P_g < 0$ , (0,0) is the ESS. This means that when the sum of the difference between strict and de security regulation in social benefits and the penalty for communication enterprises is higher than the difference between these two regulations in security regulation cost (i.e.,  $\gamma S_s - \delta S_d + P_g > C_{gs} - C_{gd}$ ) and lower than the sum of the difference between these two regulations in rent-seeking benefits, the difference of these two regulations in regulation cost, the penalty, and subsidy for communication enterprises (i.e.,  $\gamma S_s - \delta S_d + P_g < R_d + F_g + P_g - R_s + C_{gs} - C_{gd}$ ), the governments are more inclined to take de security regulation. And the additional revenue that the enterprise obtains is greater than the sum of the innovation cost it pays and the rent-seeking cost under de security regulation (i.e.,  $\Delta\pi + F_g + P_g > R_d + F_g + P_g + I_e$ ). Under this situation, the government and enterprise's strategy choice is strict security regulation, innovation.

**3.4. Situation D.** If  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ ,  $0 < \Delta\pi - I_e + F_g - R_s + P_g < R_d + F_g + P_g - R_s$ , the game equilibrium point (1,0) is the evolutionary stability point. This means the difference between the social benefits obtained when the government chooses strict security regulation and de security regulation and the sum of the fines received is less than the difference in control costs under strict security regulation and de security regulation (i.e.,  $\gamma S_s + C_{gd} + P_g < \delta S_d + C_{gs}$ ). And the sum of the additional benefits, government subsidies, and government fines obtained by the communications company is greater than the sum of the innovation costs and rent-seeking costs under strict security regulation; the additional benefits obtained by the companies are less than the innovation costs and de

security regulation and the sum of rent-seeking costs (i.e.,  $I_e + R_s < \Delta\pi + F_g + P_g$ ,  $\Delta\pi + F_g + P_g < R_d + F_g + P_g + I_e$ ). The strategy stability of the government and communication enterprises is strict security regulation, not-innovation.

**3.5. Situation E.** If  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ ,  $\Delta\pi - I_e + F_g - R_s + P_g < 0$ , the game equilibrium point (1,0) is the evolutionary stability point. This means the difference between the social benefits obtained when the government chooses strict security regulation and de security regulation and the sum of the fines received is less than the difference in control costs under strict security regulation and de security regulation (i.e.,  $\gamma S_s + C_{gd} + P_g < \delta S_d + C_{gs}$ ). And the sum of the additional revenue, government subsidies, and government fines obtained by the communications company is less than the sum of the innovation cost it paid and the rent-seeking cost during security regulation (i.e.,  $\Delta\pi + F_g + P_g < I_e + R_s$ ). At this time, the government and the company's strategy choice is strict security regulation, not-innovation.

**3.6. Situation F.** If  $\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ ,  $\Delta\pi - I_e + F_g - R_s + P_g > R_d + F_g + P_g - R_s$ , the game equilibrium point (1,1) is the evolutionary stability point. This means the difference between the social benefits obtained when the government chooses strict security regulation and de security regulation and the sum of the fines received is less than the difference in control costs under strict security regulation and de security regulation (i.e.,  $\gamma S_s + C_{gd} + P_g < \delta S_d + C_{gs}$ ). And the additional benefit that the enterprise receives is greater than the sum of the innovation cost it pays and the rent-seeking cost during de security regulation (i.e.,  $\Delta\pi + F_g + P_g > R_d + F_g + P_g + I_e$ ). Under this situation, the government and enterprise's strategy choice is strict security regulation, innovation.

#### 4. Data Simulation and Conclusions

According to the China communication industry R&D expenditure from the 2021 China Statistical Yearbook and 2021 China Statistical Yearbook on Science and Technology, the security expenditure in the communication industry refers to China's network security expenditure predicted by International Data Corporation (IDC). The ratio of China's network security expenditure to communication enterprise R&D spending is approximately equal to 3. In addition, to make calculation easy, the value is set as follows:  $\gamma = 1$ ,  $S_s = 2$ ,  $\delta = 1$ ,  $F_g = 2$ ;  $S_d = 4$  or  $5$ ,  $C_{gd} = 3$  or  $6$ ,  $C_{gs} = 2$  or  $3$ ,  $P_g = 1$  or  $2$ ,  $\Delta\pi = 1, 2, 4, 6$  or  $7$ ,  $I_e = 1$  or  $2$ ,  $R_s = 3$  or  $4$ ,  $R_d = 3$  or  $4$ . MATLAB can be programmed for the numerical simulation as shown in Table 5.

In situation A, situation B, and situation C, the premise of the strategy adopted is that the sum of the difference between the social benefits obtained when the government chooses strict security regulation and de security regulation and the fines is greater than the difference in control costs between strict security regulation and de security regulation, and the government chooses strict security regulation, and

the difference between the social benefit and the subsidy paid under the de security regulation is smaller than the sum of the difference between the control cost and the rent-seeking income obtained under the strict security regulation and de security regulation.

As shown in Figure 1, in situation A, the sum of the additional benefits, government subsidies, and government fines obtained by the communications company is greater than the sum of the innovation costs it paid and rent-seeking costs under strict security regulation; the additional benefits obtained by the company are less than the innovation costs it paid and the de security regulation and the sum of rent-seeking costs. In this situation, entrepreneurs will not have any strategic stable choices.

As shown in Figure 2, in situation B, the sum of the additional revenue, government subsidies, and government fines obtained by the communications company is less than the sum of the innovation cost it paid and the rent-seeking cost during security regulation. In this situation, the government and the company's strategy choice is de security regulation, not-innovation.

As shown in Figure 3, in situation C, the additional revenue that the enterprise obtains is greater than the sum of the innovation cost it pays and the rent-seeking cost under de security regulation. Under this situation, the government and enterprise's strategy choice is strict security regulation, innovation.

In situation D, situation E, and situation F, the strategic premise adopted is that the difference between the social benefits obtained when the government chooses strict security regulation and de security regulation and the sum of the fines received is less than the difference in control costs under strict security regulation and de security regulation.

As shown in Figure 4, in situation D, the sum of the additional benefits, government subsidies, and government fines obtained by the communications company is greater than the sum of the innovation costs and rent-seeking costs under strict security regulation; the additional benefits obtained by the companies are less than the innovation costs and de security regulation, and, for the sum of rent-seeking costs, the strategy stability of the government and communication enterprises is strict security regulation, not-innovation.

As shown in Figure 5, in situation E, the sum of the additional revenue, government subsidies, and government fines obtained by the communications company is less than the sum of the innovation cost it paid and the rent-seeking cost during security regulation. At this time, the government and the company's strategy choice is strict security regulation, not-innovation.

As shown in Figure 6, in situation F, the additional benefit that the enterprise receives is greater than the sum of the innovation cost it pays and the rent-seeking cost during de security regulation. Under this situation, the government and enterprise's strategy choice is strict security regulation, innovation.

For situations A, B, and C, we can conclude that when it is found that the government's benefits and costs meet

TABLE 5: The following table describes the results of each situation.

Situation category	Evolutionary stability point	Equilibrium condition	Assignment
Situation A	Null	$0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g$ $< R_d + F_g + P_g - R_s$ $0 < \Delta\pi - I_e + F_g - R_s + P_g$ $< R_d + F_g + P_g - R_s$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$
Situation B	(0,0)	$0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g$ $< R_d + F_g + P_g - R_s$ $\Delta\pi - I_e + F_g - R_s + P_g < 0$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$
Situation C	(1,1)	$0 < \gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g$ $< R_d + F_g + P_g - R_s$ $\Delta\pi - I_e + F_g - R_s + P_g$ $> R_d + F_g + P_g - R_s$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$
Situation D	(1,0)	$\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ $0 < \Delta\pi - I_e + F_g - R_s + P_g$ $< R_d + F_g + P_g - R_s$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$
Situation E	(1,0)	$\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ $\Delta\pi - I_e + F_g - R_s + P_g < 0$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$
Situation F	(1,1)	$\gamma S_s - \delta S_d + C_{gd} - C_{gs} + P_g < 0$ $\Delta\pi - I_e + F_g - R_s + P_g$ $> R_d + F_g + P_g - R_s$	$\gamma = 1, S_s = 2, \delta = 1, S_d = 4,$ $C_{gd} = 6, C_{gs} = 3, P_g = 2, R_d = 4,$ $F_g = 2, \Delta\pi = 4, I_e = 2, R_s = 4$

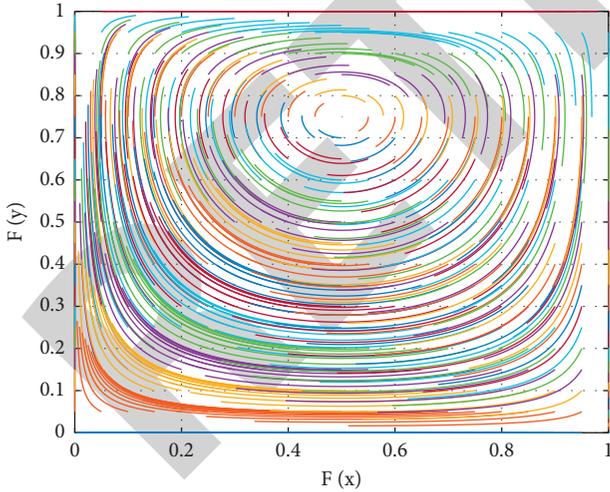


FIGURE 1: Situation A (evolutionary stability point null).

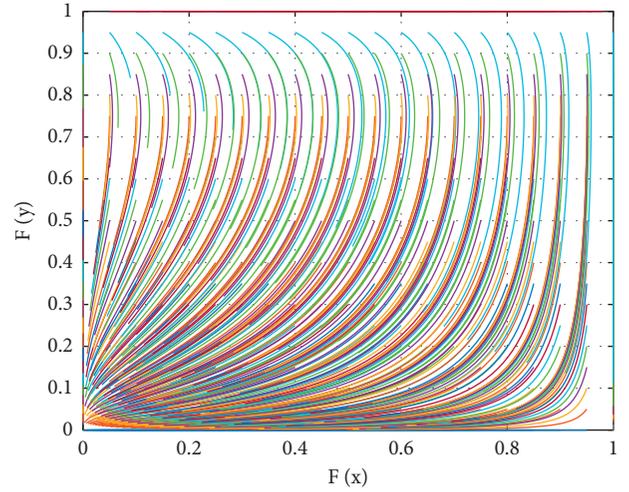


FIGURE 2: Situation B (evolutionary stability point (0, 0)).

certain conditions, as the additional benefits that innovation brings to the company increase, the company will gradually choose an innovation strategy. Because the company's innovation strategy goes from not-innovation to swing to choosing innovation; that is, a reasonable increase in innovation revenue can promote the enterprise to carry out technological innovation. For situations D, E, and F, the

government will adopt the strategy of strict control when the benefits of strict control are high. At this time, whether the enterprise's strategy changes from not-innovation to innovation mainly depends on the enough income brought by innovation. Therefore, the government's security regulation should be able to improve the innovation income of communication enterprises and guide communication

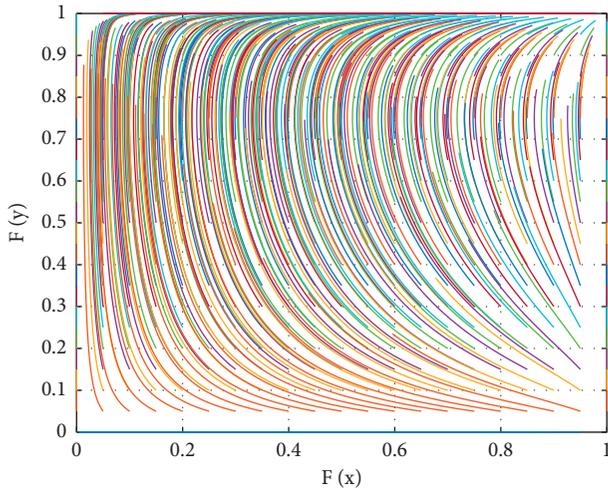


FIGURE 3: Situation C (evolutionary stability point (1, 1)).

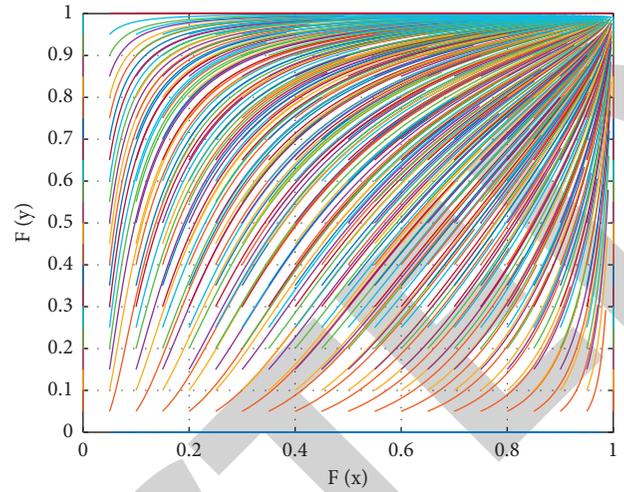


FIGURE 6: Situation F (evolutionary stability point (1, 1)).

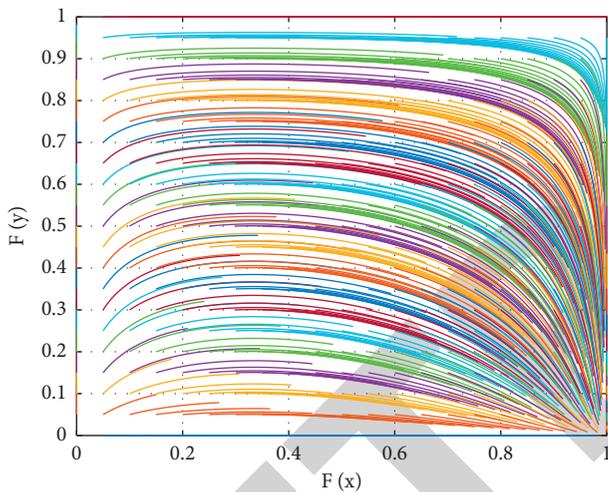


FIGURE 4: Situation D (evolutionary stability point (1, 0)).

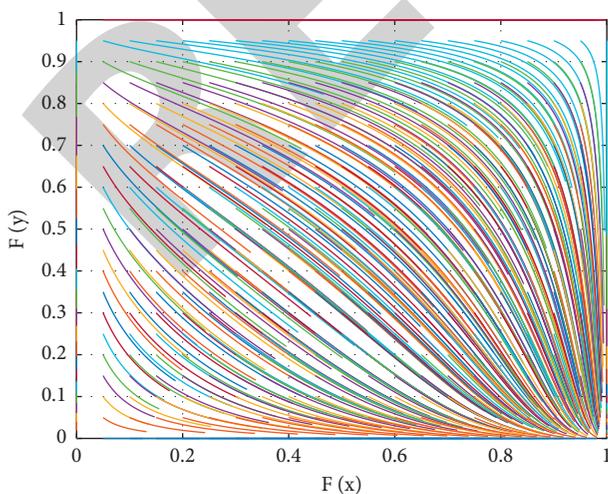


FIGURE 5: Situation E (evolutionary stability point (1, 0)).

enterprises to choose innovation strategies through government subsidies.

### 5. Conclusions

In this study, we built an evolutionary model between the governments and communication enterprises to explore the behavior of the two groups. Moreover, we analyze how the governments' policies affect the innovation strategies of communication enterprises. We found that the behavior of the governments and communication enterprises depends on their own costs and benefits. Specifically, the behavior of the governments depends on the difference between strict and de security regulation in the social difference, rent-seeking benefits, regulating costs, and the penalty and subsidy to communication enterprises. The behavior of communication enterprises depends on the benefits of innovation and the costs of R&D and rent-seeking. With the increase of benefits, participants will be more motivated to carry out innovation, especially for communication enterprises. Moreover, different policy tools provided by the governments can accelerate the implementation of communication enterprises' innovation.

The conclusions of this paper include the following. (1) In the government's supervision of the communication enterprises, both de security regulation and strict security regulation will drive innovation to have a positive or negative effect. This shows that the innovation factor affecting the communications industry is not only the government; the driving factors are more complex. (2) In the government's supervision of communication enterprises, de security regulation will appropriately lower the innovation threshold of companies, and vice versa. When the government regulates communication companies loosely, if the cost is greater than the corresponding benefit, the company will innovate, but when the government imposes strict security regulation, the conditions will be higher.

The suggestions in this paper include the following. (1) In the government's supervision of communication enterprises, under the condition of strict supervision, we should appropriately take innovation incentive measures such as government subsidies, loan preferences, and tax preferences to actively guide communication enterprises to implement innovation strategies. Because the cost of innovation and environmental uncertainty determine that innovation has certain risks, communication enterprises with too much risk will inevitably avoid innovation risks and, therefore, appropriately increase incentives to guide enterprise innovation. (2) Actively guide communication enterprises to innovate, and the government can take appropriate safety supervision measures. If the government implements strict safety supervision, it will not only increase the cost of the government but also increase the operating cost of communication enterprises. In this case, communication enterprises will not take the initiative to innovate. Therefore, before properly implementing strict safety supervision, the government can take appropriate safety supervision and create a good atmosphere for enterprise innovation.

### Data Availability

The data used to support the findings of this study are available from the author upon request.

### Conflicts of Interest

The authors declare no conflicts of interest.

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