Game Theory Analysis of Cooperation between Officers and Soldiers, Grassroots Leaders and Regulatory Agencies in Dealing with Mobile Internet Addiction

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Abstract: From a game theory perspective, this study systematically constructs a collaborative governance theoretical framework for mobile phone addiction among officers and soldiers. By establishing a tripartite game model involving officers and soldiers, grassroots leaders, and regulatory authorities, it reveals behavioral evolution patterns under different governance strategies. Based on the replicative dynamic equations of officers and soldiers, grassroots leaders, and regulatory authorities, this study further develops a three-dimensional evolutionary game system to mitigate mobile phone addiction. The study further discusses the stability of evolutionary strategy combinations and equilibrium points under their joint influence. The proactive reduction of mobile phone addiction by officers and soldiers through interactions between officers and soldiers, regulatory authorities, and grassroots leaders. Under the pressure from regulatory authorities and grassroots leadership participation, officers and soldiers demonstrate motivation to address mobile phone addiction issues.

Keywords: Mobile Network Addiction Problem; Evolution Game; Officers and Soldiers; Grassroots Leaders

1. Introduction

In military mobile network management, officers and soldiers, grassroots leaders, and regulatory bodies form a dynamic game where their strategic choices directly impact management efficiency [1-3]. Officers and soldiers seek balance between personal digital rights and disciplinary constraints, grassroots leaders must optimize policy implementation while maintaining unit stability, and regulatory bodies strive to harmonize institutional rigidity with management flexibility. Static game [4-7] dynamics often lead to an inefficient equilibrium of strict control-passive resistance-forced compliance resulting in increased administrative costs and heightened soldier resistance. A collaborative framework integrating credit incentives, flexible management, and technological empowerment achieves Pareto improvement. Regulatory bodies grant soldiers reasonable usage rights through transparent rule-making, grassroots leaders dynamically adjust management intensity based on credit evaluations, and soldiers accumulate credit points through self-discipline to gain privileges. This cooperative mechanism relies on credible commitments and information sharing. When strategy adjustments and feedback loops create a positive cycle, the system converges to a stable equilibrium, significantly enhancing management effectiveness.

2. Basic Assumptions

This study proposes the following hypotheses about the interaction between officers and soldiers, grassroots leaders and regulatory agencies in the governance of mobile Internet addiction:

Hypothesis 1: The evolutionary game system comprises three participants: officers and soldiers, grassroots leaders, and regulatory authorities. All stakeholders exhibit bounded rationality and pursue the maximization of their own interests. Under bounded rationality conditions, each participant understands the strategic spaces and payoff distributions of others. Through repeated interactions, they ultimately discover optimal strategies.

Hypothesis 2: In an evolutionary game model involving officers and soldiers, grassroots leaders, and regulatory agencies, participants are randomly paired in each round of interaction without any predetermined sequence. The strategy set for grassroots leaders consists of {Cooperate x, Non-Cooperate $1-x$}, the regulatory agency's strategy set comprises {Cooperate y, Non-Cooperate 1-y}, while the officers and soldiers' strategy set includes {Cooperate z, Non-Cooperate 1-z}.

Hypothesis 3: For grassroots leaders, when they fail to cooperate, their effort level in reducing mobile internet addiction is α, yielding a benefit of $V1$. In this scenario, grassroots leaders incur losses $S1$ and face regulatory penalties F. When actively cooperating, the cost of reducing mobile internet addiction is $C1$ with an ineffective rate weighting t. The active efforts result in self-inflicted losses $\Delta V1$. Simultaneously, grassroots leaders receive regulatory rewards $B1$ and benefit $V2$ from their efforts. For regulators, active cooperation incurs regulatory costs $C21$ and political benefits $\theta V2$. Their efforts also earn them rewards $B1$ and reduced ineffective rate weighting δ. When regulators fail to cooperate, the mobile internet addiction level reaches β, corresponding to regulatory costs βC21.

Hypothesis 4: For grassroots leaders, if the problem of mobile internet addiction affects the daily training of officers and soldiers when grassroots leaders are not cooperative, they need to pay additional penalty fees R to support officers and soldiers to complete normal training. As a result, grassroots leaders will incur training losses $S1$ and assessment losses $S2$. The probability of regulatory authorities discovering non cooperative handling of mobile internet addiction by grassroots leaders will increase due to abnormal daily training of officers and soldiers, and the corresponding losses will increase to β1-γF. When grassroots leaders actively cooperate, they will generate training benefits $V2$ and assessment benefits $V3$. For officers and soldiers, the cost of actively reducing mobile internet addiction is $C31$, the benefits they receive from training are $\pi V2$, the spiritual benefits they receive from participating are $V41$, the additional training compensation they receive is R, and the strength of their efforts to reduce mobile internet addiction is γ. When officers and soldiers do not cooperate, the loss they suffer from training is $\pi S1$.

Assumption 5: For officers and soldiers, the cost of actively participating in the supervision of regulatory authorities is $C32$, the spiritual benefits obtained from their participation are $V42$, and the incentive rewards obtained from regulatory authorities are H. For regulatory authorities, the cost of actively cooperating with regulatory authorities is $C22$, and the benefits of actively cooperating with regulatory authorities are $V5$. When regulatory authorities do not cooperate, the loss is $S3$, the degree of addiction to mobile networks is β, and the corresponding regulatory cost is $\beta C22$.

3. Evolutionary Game Model

Based on the game model hypothesis involving interactions among officers and soldiers, grassroots leaders, and regulatory authorities, the strategic interplay among these stakeholders generates eight possible outcomes, as detailed in Table 1.

Table 1. Three-Party Evolutionary Game Model

Participant		*CS x*	*NCS 1-x*
CS y	*CS z*	$(1-\delta t)(V_1-\Delta V_1)-C_1+B_1+\gamma V_3$ $\delta t(V_1-\Delta V_1)+\theta V_2-C_{21}-B_1-C_{22}+V_5-H$ $\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}+\pi V_2+H$	$(1-t)V_1-\alpha C_1-F-\gamma S_2-\gamma R$ $tV_1+F-\theta S_1-C_{21}-H$ $\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}-\pi S_1+\gamma R+H$
	NCS 1-z	$(1-\delta t)(V_1-\Delta V_1)-C_1+B_1$ $\delta t(V_1-\Delta V_1)+\theta V_2-C_{21}-B_1$ πV_2	$(1-t)V_1-\alpha C_1-F$ $tV_1+F-\theta S_1-C_{21}$ $-\pi S_1$
NCS 1-y	*CS z*	$(1-t)(V_1-\Delta V_1)-C_1+\gamma V_3$ $t(V_1-\Delta V_1)+\theta V_2-\beta C_{21}-\gamma S_3$ $\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}+\pi V_2$	$(1-t)V_1-\alpha C_1-\gamma S_2-\beta^{1-\gamma}F-\gamma R$ $tV_1-\beta C_{21}-\theta S_1+\beta^{1-\gamma}F+\gamma S_3$ $\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}-\pi S_1+\gamma R$
	NCS 1-z	$(1-t)(V_1-\Delta V_1)-C_1$ $t(V_1-\Delta V_1)+\theta V_2-\beta C_{21}$ πV_2	$(1-t)V_1-\alpha C_1-\beta F$ $tV_1-\beta C_{21}-\theta S_1+\beta F$ $-\pi S_1$

As bounded rational actors, all parties prioritize maximizing their own benefits through continuous interaction, adjustment, and strategic evolution to determine optimal strategies. Building on this framework, the study constructs replicative dynamic equations for the game model and identifies evolutionary stable strategies through solution computation. The expected payoffs and replicative dynamic equations for each stakeholder group are systematically derived from Table 1.

(1) Stability strategies of grassroots leaders

The expected benefits of cooperative strategies for grassroots leaders are:

$$\begin{aligned} U_{F1} &= yz[(1-\delta t)(V_1-\Delta V_1)-C_1+B_1+\gamma V_3] \\ &+y(1-z)[(1-\delta t)(V_1-\Delta V_1)-C_1+B_1] \\ &+(1-y)z[(1-t)(V_1-\Delta-V_1)-C_1+\gamma V_3] \\ &+(1-y)(1-z)[(1-t)(V_1-\Delta V_1)-C_1] \\ &=(1-t)(V_1-\Delta V_1)-C_1+z\gamma V_3 \\ &+y[t(1-\delta)(V_1-\Delta V_1)+B_1] \end{aligned} \tag{1}$$

The expected benefits of adopting a non-cooperative strategy for grassroots leaders are as follows:

$$\begin{aligned} U_{F2} &= yz[(1-t)V_1-\alpha C_1-F-\gamma S_2-\gamma R] \\ &+y(1-z)[(1-t)V_1-\alpha C_1-F] \\ &+(1-y)z[(1-t)V_1-\alpha C_1-\gamma S_2-\beta^{1-\gamma}F-\gamma R] \\ &+(1-y)(1-z)[(1-t)V_1-\alpha C_1-\beta F] \\ &=(1-t)V_1-\alpha C_1+(-z\beta^{1-\gamma}+z\beta-\beta)F \\ &-z(\gamma S_2+\gamma R)+y(-F+z\beta^{1-\gamma}F+\beta F-z\beta F) \end{aligned} \tag{2}$$

The average expected return for a mixed strategy by a grassroots leader is:

$$\bar{U}_F = xU_{F1}+(1-x)U_{F2} \tag{3}$$

Therefore, the dynamic equation for the replication of cooperative strategies adopted by grassroots leaders is as follows:

$$\begin{aligned} F_F(x,y,z) &= \frac{dx}{dt} = x(U_{F1}-\bar{U}_F) \\ &= x(1-x)(U_{F1}-U_{F2}) \\ &= x(1-x)[-(1-t)\Delta V_1-(1-\alpha)C_1 \\ &+(z\beta^{1-\gamma}+\beta-z\beta)F+z(\gamma V_3+\gamma S_2+\gamma R)] \\ &+x(1-x)[y(1-\delta)(V_1-\Delta V_1)+B_1 \\ &+(1-z\beta^{1-\gamma}-\beta+z\beta)F] \end{aligned} \tag{4}$$

(2) The regulatory agency's stability strategy

The expected benefits of the cooperative strategy adopted by the regulatory authorities are:

$$\begin{aligned} U_{G1} &= xz[\delta t(V_1-\Delta V_1)+\theta V_2-C_{21}-B_1] \\ &-xz[C_{22}-V_5+H] \\ &+x(1-z)[\delta t(V_1-\Delta V_1)+\theta V_2-C_{21}-B_1] \\ &+(1-x)z[tV_1+F-\theta S_1-C_{21}-H] \\ &+(1-x)(1-z)[tV_1+F-\theta S_1-C_{21}] \\ &=tV_1-\theta S_1-C_{21}+F-zH-xz(C_{22}-V_5) \\ &+x[t\delta(V_1-\Delta V_1)+\theta(V_2+S_1)-tV_1-F-B_1] \end{aligned} \tag{5}$$

The expected benefits of the regulatory agency's non-cooperative strategy are:

$$\begin{aligned} U_{G2} &= xz[t(V_1-\Delta V_1)+\theta V_2-\beta C_{21}-\gamma S_3] \\ &+x(1-z)[t(V_1-\Delta V_1)+\theta V_2-\beta C_{21}] \\ &+(1-x)z[tV_1-\beta C_{21}-\theta S_1+\beta^{1-\gamma}F-\gamma S_3] \\ &+(1-x)(1-z)[tV_1-\beta C_{21}-\theta S_1+\beta F] \\ &=tV_1-\theta S_1+\beta F+z(\beta^{1-\gamma}F-\beta F-\gamma S_3) \\ &-xz(\beta^{1-\gamma}F-\beta F)+x[\theta(V_2+S_1)-t\Delta V-\beta F] \end{aligned} \tag{6}$$

The average expected return for regulators to adopt a mixed strategy is:

$$\bar{U}_G = yU_{G1}+(1-y)U_{G2} \tag{7}$$

Therefore, the dynamic equation for the replication of the cooperative strategy adopted by regulators is:

$$\begin{aligned} F_G(x,y,z) &= \frac{dy}{dt} = y(U_{G1}-\bar{U}_G) \\ &= y(1-y)(U_{G1}-U_{G2}) \\ &= y(1-y)\{-C_{21}+(1-\beta)F \\ &-z(H+\beta^{1-\gamma}F-\beta F-\gamma S_3) \\ &-xz(C_{22}-V-\beta^{1-\gamma}F+\beta F) \\ &+x[t(\delta-1)(V_1-\Delta V_1)-B_1-(1-\beta)F]\} \end{aligned} \tag{8}$$

(3) The stability strategy of officers and soldiers

The expected benefits of cooperation strategies for officers and soldiers are:

$$\begin{aligned} U_{P1} &= xy\gamma[V_{41}-C_{31}+V_{42}-C_{32}] \\ &+xy[\pi V_2+H] \\ &+x(1-y)[\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}+\pi V_2] \\ &+(1-x)y[\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}-\pi S_1] \\ &+(1-x)y[\gamma R+H] \\ &+(1-x)(1-y)[\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}] \\ &-(1-x)(1-y)[\pi S_1-\gamma R] \\ &=\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}-\pi S_1+R \\ &+yH+x(\pi V_2+\pi S_1-\gamma R) \end{aligned} \tag{9}$$

The expected benefits of the non-cooperative strategy for the officers and men are:

$$\begin{aligned} U_{P2} &= xy(\pi V_2)+x(1-y)(\pi V_2) \\ &+(1-x)y(-\pi S_1)+(1-x)(1-y)(-\pi S_1) \\ &=x\pi V_2+(1-x)(-\pi S_1) \end{aligned} \tag{10}$$

The average expected payoff for the mixed strategy is:

$$\bar{U}_G = zU_{G1}+(1-z)U_{G2} \tag{11}$$

Therefore, the dynamic equation for the replication of cooperation strategies adopted by officers and soldiers is:

$$\begin{aligned} F_P(x,y,z) &= \frac{dz}{dt} = z(U_{P1}-\bar{U}_P) \\ &= z(1-z)(U_{P1}-U_{P2}) \\ &= z(1-z)(\gamma V_{41}-\gamma C_{31}+\gamma V_{42}-\gamma C_{32}+R) \\ &+z(1-z)(yH-x\gamma R) \end{aligned} \tag{12}$$

4. Evolutionary Game Analysis

Based on the above analysis, the strategic choices of soldiers, grassroots leaders, and regulatory agencies are interdependent [8-10]. Therefore, building upon the replicative dynamic equations of these three groups, this section constructs a three-dimensional evolutionary game dynamics system to mitigate mobile internet addiction issues. It further explores the stability of evolutionary strategy combinations and equilibrium points under their joint influence.

The three-dimensional replication dynamic system constructed in this paper is illustrated below. When addressing mobile internet addiction issues, $FF(x,y,z)=0$, $FG(x,y,z)=0$, $FP(x,y,z)=0$, dynamically adjust their strategy choices until reaching a Nash equilibrium. By using MATLAB software to compute the command parameters, and, we can obtain eight pure strategy equilibrium points for the tripartite evolutionary game.

The three-dimensional replication dynamic system constructed based on this article is shown below. When reducing the problem of mobile internet addiction, officers and soldiers, grassroots leaders, and regulatory agencies dynamically adjust their strategy choices until reaching Nash equilibrium. By using MATLAB software to calculate $FF(x,y,z)=0$, $FG(x,y,z)=0$, $FP(x,y,z)=0$, this article can obtain 8 pure strategy equilibrium points for a three party evolutionary game.

According to Lyapunov stability theory, the stability of equilibrium points can be determined through the eigenvalues of the Jacobian matrix, which also helps identify evolutionarily stable strategies [11-13]. Evolutionarily stable points are defined when all corresponding strategy combinations have negative real eigenvalues in the Jacobian matrix [14]. Based on this framework, partial derivatives with respect to x, y, and z are calculated using equations (4), (8), and (12) respectively, thereby constructing the Jacobian matrix for the three-player game.

$$\begin{bmatrix} \frac{\partial F_F(x,y,z)}{\partial x} & \frac{\partial F_F(x,y,z)}{\partial y} & \frac{\partial F_F(x,y,z)}{\partial z} \\ \frac{\partial F_G(x,y,z)}{\partial x} & \frac{\partial F_G(x,y,z)}{\partial y} & \frac{\partial F_G(x,y,z)}{\partial z} \\ \frac{\partial F_P(x,y,z)}{\partial x} & \frac{\partial F_P(x,y,z)}{\partial y} & \frac{\partial F_P(x,y,z)}{\partial z} \end{bmatrix} \tag{13}$$

On this basis, the stability of the equilibrium point is determined by the eigenvalues of the Jacobian matrix, and the detailed eigenvalues and stability are shown in Table 2.

Among which

$$E_1 = (1-t)\Delta V_1 + (1-\alpha)C_1,\ E_2 = \gamma V_3 + \gamma S_2 + \gamma R,$$

$$G = t(1-\delta)(V_1 - \Delta V_1) + B_1,$$

$$P = \gamma V_{41} - \gamma C_{31} + \gamma V_{42} - \gamma C_{32}.$$

Table 2. Stability Analysis of Evolutionary Game Model

Equantequation	Eigenvalue $\lambda 1$	Eigenvalue $\lambda 2$	Eigenvalue $\lambda 3$	Stability
E1(0,0,0)	$-E1+\beta F$	$-C21+(1-\beta)F$	$P+R$	Deny
E2(0,1,0)	$-E1+G+F$	$C21-(1-\beta)F$	$P+R+H$	Deny
E3(0,0,1)	$-E1+E2+\beta 1-\gamma F$	$-C21+(1-\beta 1-\gamma)F-H+\gamma S3$	$-P-R$	Scenario 1
E4(0,1,1)	$-E1+E2+G+F$	$C21-(1-\beta 1-\gamma)F+H-\gamma S3$	$-P-R-H$	Scenario 2
E5(1,0,0)	$E1-\beta F$	$-C21-G$	$P+R-\gamma R$	Deny
E6(1,1,0)	$E1-G-F$	$C21+G$	$P+R+H-\gamma R$	Deny
E7(1,0,1)	$E1-E2-\beta 1-\gamma F$	$-C21-H+\gamma S3-C22+V5-G$	$-P-R+\gamma R$	Scenario 3
E8(1,1,1)	$E1-E2-G-F$	$C21+H-\gamma S3+C22-V5+G$	$-P-R-H+\gamma R$	Scenario 4

In Scenario 1, when $E2+\beta 1-\gamma F<E1$, $(1-\beta 1-\gamma)F+\gamma S3<C21+H$, E3 (0,0,1) is the system's stable equilibrium. Here, grassroots leaders' efforts to reduce mobile internet addiction costs outweigh penalties from regulators, the psychological benefits gained through soldier participation, and additional training compensation. The regulatory authorities' incentives for soldier engagement and oversight expenses surpass the non-cooperative gains and penalties imposed on grassroots leaders. This situation sees grassroots leaders acting non-cooperatively, regulators remaining uncooperative, while soldiers actively cooperate. System stability then depends on intensified efforts to combat mobile internet addiction. This undesirable state indicates that although soldiers are engaged, their participation remains limited in both scope and effectiveness—a scenario that should be avoided in addiction governance.

In Scenario 2, where $E2+G+F<E1$, $C22+H<(1-\beta 1-\gamma)F+\gamma S3$, the system stabilizes at E4(0,1,1). Here, grassroots leaders' efforts to reduce mobile internet addiction costs outweigh penalties from regulators, the psychological benefits gained through soldier participation, additional training compensation, and rewards for their proactive actions. The regulatory authorities' incentives for soldier participation and oversight costs are lower than the non-cooperative benefits and penalties they impose on grassroots leaders. This scenario shows grassroots leaders being uncooperative while regulators and soldiers cooperate actively. However, this represents an undesirable state where, despite regulators 'cooperation and soldiers' engagement, grassroots leaders receive insufficient benefits and lack motivation to fulfill responsibilities – a situation to be avoided in mobile internet addiction governance. Should soldier participation decline, regulators' positive cooperation diminishes, reducing the likelihood of penalties against grassroots leaders and causing the system to revert to Scenario 1. Overall, system stability in this case depends on soldier participation intensity.

In Scenario 3, where $E1<E2+\beta1-\gamma F$ and $\gamma S3+V5<G+C21+H+C22$, the system stabilizes at E7 (1,0,1). Here, grassroots leaders 'efforts to reduce mobile phone addiction costs are less effective than penalties imposed by regulators, the psychological benefits gained through soldier participation, and additional training compensation. The regulatory authorities' incentives for soldier participation and their own regulatory costs outweigh the non-cooperative benefits and penalties received by grassroots leaders. This scenario depicts a suboptimal state where grassroots leaders cooperate, regulators remain inactive, and soldiers actively collaborate. Regulators fail to fulfill their role in this context. In this situation, soldier participation primarily focuses on grassroots leaders 'proactive responsibility fulfillment for reducing mobile phone addiction, while regulatory incentives remain weak. However, soldier participation struggles to impose high constraints on addiction reduction, as significant engagement and monetization of participation rights require substantial costs—contradicting soldiers' pursuit of broader social engagement beyond mobile phone addiction. Should soldier participation weaken, grassroots leaders 'benefits from proactive responsibility fulfillment diminish, causing the system to revert to Scenario 1. Overall, system stability in this case depends on both soldiers' participation intensity and the regulatory authorities' penalty effectiveness.

In Scenario 4, when the system configuration is $E1-E2-G-F<0$, $C21+H-\gamma S3+C22-V5+G<0$, E8 (1,1,1) represents a stable equilibrium state. Here, grassroots leaders actively reduce mobile internet addiction costs at a lower threshold than when penalties from regulatory authorities, military personnel's participation in mental benefits and additional training compensation, or grassroots leaders' incentives for reducing addiction issues are considered. The regulatory authorities' costs of incentivizing participation and oversight are lower than the non-cooperative benefits and penalties received by grassroots leaders. This scenario demonstrates cooperation among grassroots leaders, regulators, and military personnel—a desirable state where all parties work synergistically to maintain system stability. Notably, although these stakeholders exhibit coordinated effects, the dynamics between military engagement intensity, regulatory oversight rigor, and leadership commitment remain dynamically interactive. All entities may strategically pursue higher benefits or lower costs through coordinated actions.

5. Pathways for the Cooperation of Soldiers, Grassroots Leaders and Regulatory Agencies in Addressing Mobile Internet Addiction

The analysis reveals that military personnel's proactive efforts to reduce smartphone addiction stem from interactions with regulatory bodies and grassroots leaders. Under pressure from both regulatory authorities and grassroots engagement, soldiers develop motivation to address this issue. However, when the benefits of compliance outweigh the costs—particularly when penalties or rewards fail to justify the necessary measures—individuals may opt for passive compliance (non-cooperation). This collaborative approach where regulators, leaders, and service members work together to reduce smartphone addiction not only generates additional benefits but also creates shared incentives for accountability. Therefore, effective governance of smartphone addiction requires coordinated efforts from regulatory agencies, grassroots leaders, and service members.

(1) For regulatory authorities, situations involving either sole reliance on grassroots leaders, military personnel alone, or interactions between both groups present instability in evolutionary game systems. To address smartphone addiction issues, regulators must establish policies and enforce regulations to constrain and guide military personnel's behavior. Under the profit-maximization principle, such regulation internalizes external environmental

costs of smartphone addiction for soldiers, directly increasing compliance costs that suppress their enthusiasm and training motivation. Conversely, adopting the profit-maximization approach requires incorporating this regulation into a dynamic process. In the long run, this strategy not only boosts soldiers' training engagement to sustain military development but also enhances combat effectiveness.

(2) For military personnel, the evolutionary game system remains unstable under regulatory oversight and grassroots leadership accountability, regardless of their participation. Since regulatory incentives and disciplinary measures may fail to adequately address the costs of grassroots leaders' responsibility fulfillment in combating mobile internet addiction, these leaders might opt for passive compliance. To mitigate information asymmetry between regulators and grassroots leaders, enhance regulatory effectiveness and benefits while increasing accountability incentives, military personnel need to engage in addressing mobile internet addiction. However, limited participation capacity and willingness among personnel restrict their involvement. While such engagement could potentially reduce addiction issues, current low participation levels make this approach ineffective. This indicates that although military participation can help mitigate mobile internet addiction, it remains more dependent on regulatory mechanisms from authorities.

(3) For grassroots leaders, the regulatory game system becomes unstable when governed by supervisory authorities and supported by military personnel. This implies that addressing mobile internet addiction requires grassroots leaders to actively fulfill their responsibilities. However, as these leaders are driven by self-interest, they may prioritize personal gains over public duty when implementing anti-addiction measures. The costs for grassroots leaders in addressing mobile internet addiction include not only direct expenses but also regulatory incentives and additional benefits from successful interventions. Therefore, under regulatory pressure and with military participation, grassroots leaders must consider both the costs of addressing mobile internet addiction and develop refined management strategies to enhance accountability in this critical issue.

6. Conclusions

From a game theory perspective, this study systematically constructs a collaborative governance theoretical framework for mobile phone addiction among young military personnel. By establishing a tripartite game model involving personnel, grassroots leaders, and regulatory authorities, it reveals behavioral evolution patterns under different governance strategies. Based on the replicative dynamic equations of personnel, grassroots leaders, and regulatory authorities, we further develop a three-dimensional evolutionary game system to mitigate mobile phone addiction. The study further discusses the stability of cooperative strategy combinations and equilibrium points among these stakeholders. The proactive reduction of mobile phone addiction by personnel stems from interactions between personnel and regulatory authorities, as well as grassroots leaders. Under pressure from regulatory authorities and grassroots leaders, personnel exhibit motivation to reduce addiction. However, when driven by the principle of maximizing benefits, if the penalties faced or rewards obtained cannot justify the expenditure for addiction reduction, personnel may opt for passive compliance (non-cooperation). Therefore, through collaborative efforts to actively reduce mobile phone addiction, regulatory authorities, grassroots leaders, and personnel can generate additional benefits for individuals, collectively motivating them to fulfill their responsibilities in minimizing mobile phone addiction.

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