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Research Article

Emergency Volunteer Participation in the Evolutionary Game of Public Security Governance under Community Incentives

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The outbreak of the COVID-19 epidemic has brought profound changes to all aspects of our society and also reflects the importance of community emergency volunteers actively participating in epidemic prevention and control in the face of unexpected public security events. As a bridge between the implementation of government policies and the masses of the community, community emergency volunteers have the characteristics of high efficiency and low cost, which has a great impact on the advancement of modern social governance. In order to motivate volunteers, the community will introduce incentive mechanisms. How does the evolutionary process of a dynamic game between volunteer engagement and community motivation change? How should communities maximize the service investment of volunteers in the game process? However, the current research rarely focuses on the role of community volunteers in the modernization of Community Governance. In order to clarify this game process, this article constructs a public safety governance incentive game model consisting of communities and emergency volunteers. Based on evolutionary game theory, we obtain the evolutionary stable equilibrium point by solving the replicator dynamic equations of all parties in the dynamic system under different constraints. Finally, some numerical examples were provided to simulate the selection of agents. The research results show that the degree of community public security risk, the degree of active involvement of volunteers, the degree of inactive involvement of volunteers, and the level of community incentives have an important impact on the enthusiasm of volunteer community service investment decision-making behavior. In addition, the choice of community incentive-volunteer service investment strategy is a dynamic process, which can converge to the ideal state under certain conditions after continuous adjustment and optimization. In addition, this study puts forward suggestions and measures conducive to the game between both sides, which can provide valuable guidance for the practice of community public security governance and the improvement of government efficiency in China.

1. Introduction

The COVID-19, which broke out in 2019, was characterized as a public health and safety emergency due to its widespread and fast speed. In this epidemic, volunteers are undoubtedly the closest group to the epidemic, and also the deep participants in this sudden public security event. Volunteers have played a huge role in the process of community public security governance. Local community residents spontaneously formed volunteer service teams to actively assist community staff in carrying out prevention and control policy publicity, control of people returning from other places to touch the platoon at home and community mutual assistance activities, such as purchasing and distribution of residents' living goods, to maintain the harmony and stability of the community and the basic life of residents [1]. Community emergency volunteers have gradually been recognized, as an important part of Community Governance, playing an irreplaceable role in promoting the modernization of grass-roots social governance. First of all, from the perspective of service object, the primary object of community volunteer service is mainly the elderly, the disabled, single-parent families, and other vulnerable groups, which to a large extent make up for the lack and imbalance of social and public welfare provided by the government [2]. Second, from the perspective of improving

the level and capacity of Community Governance, community service will undoubtedly help improve the grass-roots Community Governance system. Volunteer service can improve their social participation in handling social affairs, promote and mobilize community residents to participate in grass-roots Community Governance and community problem solving, so as to achieve the purpose of improving the community autonomy ability of grass-roots residents and improve the community autonomy system [3]. Finally, from the perspective of social effects of community volunteer service, in the process of serving the community, volunteers' behavior can not only alleviate the plight of the help group but also obtain their own emotional satisfaction in the process. Therefore, community voluntary service can not only promote the spread of positive social energy but also play an important role in improving social cohesion and maintaining social stability at the grass-roots level [4].

However, there are still many challenges in how to motivate volunteers to participate in community public security governance. According to Freud's personality theory [5], emergency volunteers' investment in community public governance is not completely rational, and volunteers often bear a large sunk cost when they invest in community services, and voluntary services without income are difficult to meet the survival needs of volunteers, thereby affecting their enthusiasm for investment. At the same time, as an important support resource, the effectiveness of prevention and control of community's sudden safety accidents depends on the enthusiasm of volunteer service. Therefore, the community introduces an incentive mechanism for volunteer service behavior to fully mobilize the enthusiasm of volunteer service. The introduction of incentive measures will increase the cost of the community, so the degree of incentive introduced needs to be weighed by the community. However, the fundamental purpose of community and volunteer participation in the game is to maximize their own interests, and their strategic choices must be judged based on the ultimate benefits they obtain. The final game result is a dynamic and changing process. The study constructs an evolutionary game model of community platform incentive and volunteer service investment in the context of Community Governance modernization, discusses the evolutionary stability strategy (ESS) under different modes, and provides suggestions for improving the level of Community Governance in China [6, 7]. This article explores the role of social volunteer services in the governance system based on evolutionary game theory and uses numerical simulations for illustration [8]. The contribution of this article is twofold: first, based on the relationship between community volunteer service investments, it describes the relationship between the main investment roles in social cogovernance; the second is to construct a game model to explore and analyze the dynamic game process between communities and volunteers under the promotion of social cogovernance. The research results not only reveal the dynamic process between community incentives and volunteer service investment but also provide reference for communities to develop appropriate incentive measures, thereby optimizing the level of community cogovernance.

Specifically, the rest of the study is organized as follows. We introduce the literature review in Section 2. In Section 3, the evolutionary game model between community incentives and community service input of emergency volunteers is constructed and the evolutionary stability of the game model is discussed. The numerical simulation results are reported in Section 4. Section 5 describes the conclusions of this study.

2. Literature Review

2.1. Research on Community Governance Model. As the basic unit of social management, "community" has begun to enter people's vision. The main body of voluntary service activities is the community people, who conduct self-management and self-service [9]. The United Nations has always attached great importance to the development of 'communities,' aiming at meeting the actual interests and survival needs of residents, taking the government and the community as the main body and the community as the platform, coordinating the resources of all parties, comprehensively utilizing them, and continuously improving the overall development level from the aspects of community economy, society, and culture [10]. At present, the models of Community Governance in foreign countries are mainly divided into three categories: the first is the type of residents' autonomy that "the government accounts for less and the society accounts for more." Under this concept, Community Governance is mainly manifested in the great role of voluntary service organizations, and the management of the community is organized and based on the law [11]. The second is the type of government governance dominated by "more government and less society," which is mainly manifested in the clear guiding function of the government, the perfect Community Governance system, and the emphasis on residents' autonomy under the guidance of the government [12]. The third is the cooperative type of "the proportion of the government is equal to that of the society." This governance mode is also called "community building." This special governance mode is based on the existing resources of the regional society. By activating these resources, the multiagent and multiagent cooperation of Community Governance can organize diverse activities to achieve the purpose of improving the living standards of residents, the level of Community Governance, and the living environment around [13]. The Community Governance model of "community building" is constantly developing, and its scope of participation is also expanding, including not only the government and nonprofit organizations but also the community residents. Fuente-Carasco believes that Community Governance is independent, and its purpose is to serve the development of the community and the needs of the residents. First, the government makes use of resources to lay the foundation for governance; second, voluntary service organizations participate in governance according to the law; third is to establish and improve the incentive mechanism for participation in governance, and cultivate the enthusiasm of the government, voluntary service organizations, and communities to participate [14]. Based on

the actual situation of Community Governance, find out the common problems, and on the basis of gradually improving the system of voluntary service organizations' participation in governance, improve their own capabilities to promote community development [15].

2.2. Research on the Motivation of Volunteer Service. According to the logical relationship between "motivation and motivation," foreign scholars believe that the motivation of volunteers is targeted, so they divide the needs of voluntary service motivation into three major models: the two-factor model of voluntary service motivation, the three-factor model of voluntary service motivation, and the multifactor model of voluntary service motivation. The first is to analyze the two factor models of volunteer motivation, that is, the two-factor model analysis. Horton Smith first proposed two different motivation models, namely, egoistic motivation and altruistic motivation. In this model, egoistic motivation is to approach others to meet social needs, while altruistic motivation is to sympathize with others [16]. Chenhall et al. divided the service motivation of volunteers into altruism and self-interest and believed that the social service motivation of volunteers was mainly to meet specific needs and assist institutions to achieve common goals. Third, some scholars have classified volunteer motivation into three categories, but the classification methods are different. Fitch compiled voluntary service activities, selected college students as the research object, and drew three main motives: self-interest, altruism, and social responsibility [18]. Ziemek believes that volunteers are an ideal social and economic behavior. Their motivation distribution is affected by the country's economic development level and population characteristics. In addition to self-interest and altruism motivation, they also put forward investment motivation [19]. Adam divided the motivation of volunteers into three paradigms: altruism, civil relations, and leisure volunteers [20]. He believes that to help community residents and develop community services, volunteers need to go to the streets. Finally, some scholars have carried out more classifications of volunteer motivation, reaching six types. Clary, a famous American scholar, first put forward six motives of voluntary service: understanding, protection, expression of value, professional motivation, social motivation, and self-improvement, and believed that each motive has its corresponding value role [21]. Based on these six motivations for voluntary service, Clary developed the most widely used volunteer functions inventory (VFI), which gained a high degree of trust and effectiveness (VFI) in the research behind voluntary motivation. Parker set up a scientific questionnaire and concluded that the motivation of volunteer service is divided into four parts: altruism, mutual assistance, faith, and rest [22].

2.3. Research on Volunteer Motivation. Osborne et al. pointed out that volunteers need to build internal and external incentive mechanisms for voluntary service if they want to gain a sense of self-honor, organizational identity, and personal growth and progress. From the perspective of individual volunteers, such as incentive and sense of honor incentive are an internal incentive mechanism, while external incentive mechanism is to adhere to the principle of fairness to complete complex tasks, creating a good environment for volunteers to provide services [23]. Importantly, it is also necessary to integrate the whole process of volunteers into social security. Dacombe found that a sound volunteer group needs a perfect incentive mechanism to support it by studying the management system, role, and selfless dedication of volunteers. Building an incentive mechanism for voluntary service is so important that it needs the joint efforts of the government, society, and individuals [24]. Knoke proposed that the incentive mechanism of volunteers should conform to their values, and the closer the motivation of volunteers is to their interests, the more their ability, material, time, participation, and social resources they think are valuable will be [25]. McGovern pointed out that only when the voluntary service institutions combine the individual interests and interests of volunteers, the values of life and the incentive needs of volunteers to serve the society, can the potential of volunteers be better played and can they better serve and contribute to the society [26].

3. Model Construction and Analysis

The selection of community incentives-volunteer service investment strategies is a process of continuous game play, adjustment, and optimization between both parties. As the game process occurs, it often accompanies situations where the community adopts incentives, where volunteers are not active, the community adopts incentives, volunteers are active, the community does not motivate, volunteers are active, and the community does not motivate, and volunteers are not active. During the COVID-19, the Community Governance of a community in Datian County, Fujian Province, China, was faced with community incentives, and volunteers were not active. Although the community's governance committee implemented some incentive measures, but not limited to providing certain remuneration and benefits, the volunteers' enthusiasm was still low. In order to solve this problem, the Community Governance committee negotiated and cooperated with several volunteer service organizations during the COVID-19 epidemic. We have jointly developed the "Volunteer Service Points System" as a new incentive measure for volunteer services. This system stipulates that volunteers can earn certain points in community services. After accumulating certain points, volunteers can exchange them for certain rewards, such as gifts and volunteer service certificates. With the introduction of new incentive measures, the enthusiasm of volunteers to participate in community services has significantly improved. The Community Governance committee has developed an internet-based volunteer service management system to monitor and evaluate the service of volunteers in real time. The promotion and operation of the volunteer service credit system has promoted the collaboration between the Community

Governance committee and volunteer service organizations, strengthened the enthusiasm of volunteers to a certain extent, and promoted the change of volunteer service attitude from negative to positive.

In response to community incentives and active volunteer service, the American Red Cross Los Angeles Branch has been established in Los Angeles, California, USA, and a series of emergency volunteer programs has been implemented. The organization helps volunteers prepare for various emergency situations through online training, onsite training, and emergency drills and provides a volunteer management system to organize and allocate volunteers. At the same time, they also provide rich incentive measures for volunteers, such as accumulating equity points, which can be exchanged for thank you cards, commemorative prizes, bonuses, and other special rewards. These incentive measures have stimulated more people to actively participate in volunteer actions and provide better services to the community. At the same time, Japan's "My Family has a Little Guard" volunteer service project provides volunteers with certain material rewards and long-term service opportunities to motivate them to actively participate in volunteer behavior, be responsible for community safety maintenance, and problem handling. The volunteer service content involves patrolling evacuation routes, monitoring emergency situations such as disasters, and providing emergency assistance. The establishment of these projects and these incentive measures has attracted a large number of volunteers to participate. They actively participate in evacuation and security work and support the smooth progress of emergency rescue work.

In response to the lack of incentives in the community and the active participation of volunteers in services, a 7.0 magnitude earthquake occurred in Lushan County, Ya'an City, Sichuan Province, in 2013. At that time, many communities spontaneously organized and participated in rescue operations, including many emergency volunteers. Especially a woman named Wang Xiuying, who is a local television worker. After the earthquake, she did not wait for instructions from the organization and started to rescue herself. She constantly ran between various disaster areas, delivering supplies and assistance to the affected people for 5 consecutive days without any form of subsidies or incentives. She only actively participated in the rescue work because of her love and responsibility. Regarding the situation where the community is not incentive and volunteers do not actively participate in services, although some volunteers have registered to participate in voluntary service activities in the early stage, in actual service activities, due to insufficient understanding of the danger and difficulty of voluntary action in the early stage, it is found that voluntary action is very dangerous and difficult in the actual process, and due to the assumption of noncompletely rational individuals, there may be a decrease in voluntary service enthusiasm at this time.

Based on the analysis of the abovementioned four cases, it is found that different forms of incentive measures such as point rewards, cash rewards, and honor rewards are adopted for different communities with different levels of emergency rescue urgency and tasks. Correspondingly, emergency volunteers will also adopt different behavioral measures such as positive and negative. At the same time, the degree of volunteer participation will also have a negative impact on the modification and adjustment of community incentive measures, whether the level of community incentives is too high or too low is not conducive to volunteer participation or investment. Therefore, it is urgent to study and analyze how to motivate volunteers to participate in community public safety governance, especially to explore how to adopt incentive measures, what incentive measures to take, and whether incentive measures are appropriate. Therefore, this article aims to systematically explore the synergistic relationship between community incentives and volunteer service investment in order to obtain a comprehensive accurate conclusion.

3.1. Evolutionary Game Model. As a basic component of urban governance, communities have played an important role in preventing and controlling the epidemic. The downward movement of emergency volunteer service forces can effectively slow down the spread of the epidemic and control the social problems caused by the epidemic at the community level, thus minimizing the adverse effects of major public safety emergencies. However, in real life, the community and volunteers are not completely rational. Volunteers often bear a large sunk cost when they invest in community services, which affect their enthusiasm. However, the effectiveness of prevention and control of sudden safety accidents in the community depends on the enthusiasm of volunteer service. Therefore, the community introduces an incentive mechanism for volunteer service behavior to fully mobilize the enthusiasm of volunteer service. This paper constructs an evolutionary game model between the community and volunteers to explore the dynamic changes in volunteer service behavior.

To better reveal the essence and make the model more reasonable without affecting the conclusion, four assumptions are proposed:

Hypothesis 1: the probability of the community becoming a high-risk community during the epidemic is p, and the probability of becoming a low-risk community is $1 - p$.

Hypothesis 2: the cost of community incentive volunteer service investment is c. When volunteers are motivated to participate in voluntary service, the cost of investment is kq_1. When the volunteer service input is not active, the input cost is kq_2, where $q_1 > q_2$.

Hypothesis 3: if volunteers actively participate in community epidemic prevention services, when the community is a low-risk community, the benefits of the community from volunteer services are $l_1 q_1$. When the community is a high-risk community, the benefits of the community from volunteer services are $l_2 q_1$, where $l_2 > l_1$.

Hypothesis 4: If volunteers choose not to actively participate in community epidemic prevention

services, when the community is a low-risk community, the benefits of volunteers' inactive participation in services to the community are l_1q_2. When the community is a high-risk community, the benefits brought to the community by volunteers who do not actively participate in the service are l_2q_2, where $l_2 > l_1$.

Based on the assumption of bounded rationality, we build a function matrix based on the game model, as shown in Table 1, to discuss how the community incentives and volunteer input behavior change dynamically. In this evolutionary model, we use $\{x, 1-x\}$ to represent the probability set of community incentives, and $\{y, 1-y\}$ represents the probability set of volunteers' active participation.

According to the hypothesis of this paper, when the community encourages volunteers and volunteers actively participate (a_1, b_1), the benefits of both are

$$\begin{aligned} a_1 &= p(l_2q_1 - c) + (1-p)(l_1q_1 - c) \\ b_1 &= c_1 - kq_1. \end{aligned} \tag{1}$$

When the community encourages volunteers, but volunteers are not actively involved (a_2, b_2), the benefits of both are

$$\begin{aligned} a_2 &= p(l_2q_2 - c) + (1-p)(l_1q_2 - c) \\ b_2 &= c_1 - kq_2. \end{aligned} \tag{2}$$

When the community does not encourage volunteers, but volunteers are actively engaged (a_3, b_3), the benefits of both are

$$\begin{aligned} a_3 &= pl_2q_1 + (1-p)l_1q_1 \\ b_3 &= -kq_1. \end{aligned} \tag{3}$$

When the community does not motivate volunteers and volunteers do not actively participate (a_4, b_4), the benefits of both are zero.

To make the model easier to understand and clear, the variables and parameters in this paper are summarized in Table 2.

3.2. Dynamic Evolution Game Analysis of Community. According to the evolutionary game payment matrix, the expected benefits of community incentives to volunteers in the epidemic prevention and control process are [27, 28]

$$U_{11} = ya_1 + (1-y)a_2. \tag{4}$$

The expected benefits of the community's adoption of incentives are as follows:

$$U_{12} = ya_3 + (1-y)a_4. \tag{5}$$

According to formulas (4) and (5), the average income of the community is

$$\begin{aligned} \overline{U}_1 &= xU_{11} + (1-x)U_{12} \\ &= x(ya_1 + (1-y)a_2) + (1-x)(ya_3 + (1-y)a_4). \end{aligned} \tag{6}$$

Table 1: Income matrix of evolutionary game between community and volunteers.

		Volunteer	
		Positive (y)	Inactive $(1-y)$
Community	Encourage (x)	a_1, b_1	a_2, b_2
	Disincentive $(1-x)$	a_3, b_3	a_4, b_4

Therefore, the replication dynamic equation of community incentives for volunteers in the process of epidemic prevention and control can be expressed as follows:

$$\begin{aligned} F(x) &= \frac{dx}{dt} \\ &= x(U_{11} - \overline{U}_1) \\ &= x(1-x)(U_{11} - U_{12}) \\ &= x(1-x)(y(a_1 - a_3) + (1-y)(a_2 - a_4)). \end{aligned} \tag{7}$$

In order to obtain the stable strategy of evolutionary game, we need to find the equilibrium point of the replication dynamics equation, that is, the equilibrium point x^*. The equilibrium point x^* needs to meet two conditions: $F(x^*) = 0$ and $F'(x^*) < 0$. Let $F(x) = 0$, we can get $x^* = 0, x^* = 1$, and $y^* = (q_2(p(l_1 - l_2) - l_1) + c)/(pl_2q_1 + q_2(p(l_1 - 2l_2) - l_1))$. Let $M_1 = q_2(p(l_1 - l_2) - l_1) + c$ and $N_1 = pl_2q_1 + q_2(p(l_1 - 2l_2) - l_1)$:

When $y^* = N_1/M_1$ and $F(x) \equiv 0$, currently, it is a stable equilibrium strategy for any x.

When $y^* \neq N_1/M_1$, the stable equilibrium strategy may be $x^* = 0$ or $x^* = 1$.

Therefore, we take the derivative of $F(x)$:

$$\begin{aligned} F'(x) &= \frac{dF(x)}{dx} \\ &= (1-2x)(yM_1 - \mathrm{N}_1). \end{aligned} \tag{8}$$

If $y < y^*$, there is $(yM_1 - \mathrm{N}_1) < 0$, then $(dF(x)/dx)|x = 0 < 0$, $(dF(x)/dx)|x = 1 > 0$, thus $x = 0$ is a stable evolution strategy.

If $y > y^*$, there is $(yM_1 - \mathrm{N}_1) > 0$, then $(dF(x)/dx)|x = 0 > 0$, $(dF(x)/dx)|x = 1 < 0$, thus $x = 1$ is a stable evolution strategy.

3.3. Dynamic Evolutionary Game Analysis of Volunteers. According to the payment matrix of the evolutionary game, the expected benefits obtained by volunteers when actively participating in the epidemic prevention and control process are

$$U_{21} = xb_1 + (1-x)b_3. \tag{9}$$

The expected benefits of the volunteers' nonincentive measures are as follows:

Table 2: Symbols and variable descriptions.

Parameter	Description
p	The probability that the community is a high-risk community
c	The community encourages the input of volunteers
q_i	The degree of active involvement of volunteers $(i = 1, 2)$
k	Unit cost of volunteer services
l_i	Unit benefits of community receiving volunteer services $(i = 1, 2)$
x	Probability of community choice incentives
y	Probability of volunteers choosing to actively participate in the service

$$U_{22} = xb_2 + (1 - x)b_4. \tag{10}$$

Therefore, the average expected income of volunteers is

$$\overline{U}_2 = yU_{21} + (1 - y)U_{22}. \tag{11}$$

According to formulas (9)–(11), the replication dynamic equation of volunteers actively participate in services under the community incentive policy is

$$\begin{aligned} F(y) &= \frac{dy}{dt} \\ &= y\left(U_{21} - \overline{U}_2\right) \\ &= y(1 - y)\left(U_{21} - U_{22}\right) \\ &= y(1 - y)\left(x\left(b_1 - b_2\right) + (1 - x)b_3\right). \end{aligned} \tag{12}$$

To obtain the stable strategy of evolutionary game, we need to find the equilibrium point of replication dynamics equation, that is, the equilibrium point y^*. The equilibrium point y^* needs to meet two conditions: $F(y^*) = 0$ and $F^{'}(y^*) < 0$. Let $F(y) = 0$, we can get $y^* = 0$, $y^* = 1$, and $x^* = q_1/q_2$.

When $x^* = q_1/q_2$ and $F(y) \equiv 0$, currently, it is a stable equilibrium strategy for any y.

When $x^* \neq q_1/q_2$, the stable equilibrium strategy may be $y^* = 0$ or $y^* = 1$.

Therefore, we take the derivative of $F(y)$:

$$\begin{aligned} F^{'}(y) &= \frac{dF(y)}{dy} \\ &= (1 - 2y)\left(xkq_2 - kq_1\right). \end{aligned} \tag{13}$$

If $x < x^*$, then there is $(xq_2 - q_1) < 0$, then $(dF(y)/dy)|y = 0 < 0$, and $(dF(y)/dy)|y = 1 > 0$ which shows that $y = 0$ is a stable evolution strategy.

If $x > x^*$, then there is $(xq_2 - q_1) > 0$, then $(dF(y)/dy)|y = 0 > 0$, and $(dF(y)/dy)|y = 1 < 0$ which shows that $x = 1$ is a stable evolution strategy.

3.4. Evolutionary Game Analysis of Both Sides. The above-mentioned sections separately discuss the ESS of community and emergency volunteers in the process of voluntary activities facing emergencies. However, because the behavior of the organizational members will influence each other and there are random disturbance factors in the process of voluntary activities that affect the voluntary service behavior of the members, this section uses the replication dynamic equations of two groups of members to obtain the dynamic equilibrium solution of both sides in the process of voluntary service cooperation and analyze the stability of the equilibrium point through the Jacobian matrix. The Jacobian matrix of the evolutionary game model is shown in formula (14), where the determinant and trace of each equilibrium point are calculated as formulas (15) and (16), respectively [29]:

(1) When $M_1 < N_1$ and $q_2 < q_1$. There are four equilibrium solutions in the dynamic evolution game equations between two organizational members: $A(0, 0), B(1, 0), C(1, 1)$, and $D(0, 1)$. The stability analysis results of these four equilibrium points are shown in Table 3:

According to Table 3, the evolutionary game system of stability strategy can be obtained. As shown in Figure 1, the evolutionary game system converges to the equilibrium point $A(0, 0)$, that is, the community does not take incentives and volunteers do not actively participate in services.

When $M_1 < N_1$ and $q_2 < q_1$

(2) When $M_1 < N_1$ and $q_2 > q_1$. There are four equilibrium solutions in the equation system between two organization members: $A(0, 0), B(1, 0), C(1, 1)$, and $D(0, 1)$. The stability analysis results of these four equilibrium points are shown in Table 4:

According to Table 4, we can draw the evolutionary game system of two members' stability strategies, as shown in Figure 2. It is better for the community not to take incentives than to take incentives, but for volunteers, the enthusiasm of participating in community services is affected by community strategies. When $x > x^*$, volunteers tend to participate actively; at that time, when $x < x^*$, the enthusiasm of volunteers gradually decreased, and he would gradually tend to be inactive. In this case, the evolutionary game system of both sides converges to point $A(0, 0)$.

(3) When $M_1 > N_1$ and $q_2 < q_1$. There are still four equilibrium solutions in the dynamic replication equation system between two organizational members: $A(0, 0), B(1, 0), C(1, 1)$, and $D(0, 1)$. The stability analysis results of these four equilibrium points are shown in Table 5:

Table 3: Stability analysis of equilibrium point when $M_1 < N_1$ and $q_2 < q_1$.

Equilibrium point	Det (J)		$Tr(J)$		Stability
$A(0,0)$	kN_1q_1	+	$-(N_1 + kq_1)$	−	ESS
$B(1,0)$	$N_1k(q_2 - q_1)$	−	$N_1 + k(q_2 - q_1)$	Indeterminacy	Saddle point
$C(1,1)$	$(N_1 - M_1)k(q_1 - q_2)$	+	$(N_1 - M_1) + k(q_1 - q_2)$	+	Unstable saddle point
$D(0,1)$	$(M_1 - N_1)kq_1$	−	$(M_1 - N_1) + kq_1$	Indeterminacy	Saddle point

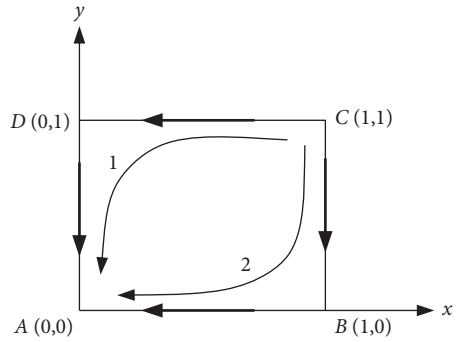

Figure 1: Stability strategy of evolutionary game system.

Table 4: Stability analysis of equilibrium point when $M_1 < N_1$ and $q_2 > q_1$.

Equilibrium point	Det (J)		$Tr(J)$		Stability
$A(0,0)$	N_1kq_1	+	$-(N_1 + kq_1)$	−	ESS
$B(1,0)$	$N_1k(q_2 - q_1)$	+	$N_1 + k(q_2 - q_1)$	+	Unstable saddle point
$C(1,1)$	$(N_1 - M_1)k(q_1 - q_2)$	−	$(N_1 - M_1) + k(q_1 - q_2)$	Indeterminacy	Saddle point
$D(0,1)$	$(M_1 - N_1)kq_1$	−	$(M_1 - N_1) + kq_1$	Indeterminacy	Saddle point

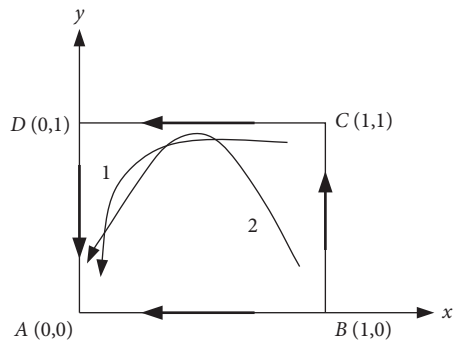

Figure 2: Stability strategy of evolutionary game system when $M_1 < N_1$ and $q_2 > q_1$.

Table 5: Stability analysis of equilibrium point when $M_1 > N_1$

Equilibrium point	Det (J)		$Tr(J)$		Stability
$A(0,0)$	N_1kq_1	+	$-(N_1 + kq_1)$	−	ESS
$B(1,0)$	$N_1k(q_2 - q_1)$	+	$N_1 + k(q_2 - q_1)$	Indeterminacy	Saddle point
$C(1,1)$	$(N_1 - M_1)k(q_1 - q_2)$	−	$(N_1 - M_1) + k(q_1 - q_2)$	Indeterminacy	Saddle point
$D(0,1)$	$(M_1 - N_1)kq_1$	−	$(M_1 - N_1) + kq_1$	+	Unstable saddle point

According to Table 5, the evolutionary game system of both stability strategies is shown in Figure 3. The probability of volunteers not actively participating in the service is greater than that of the active participation strategy. The stable and balanced strategy of volunteers is not actively participating in the community service, but whether the community takes incentive measures. When $y > y^*$,

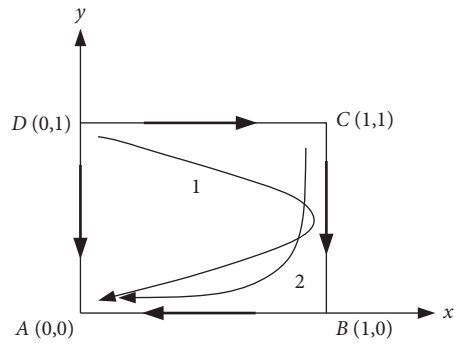

Figure 3: Stability strategy of evolutionary game system when $M_1 > N_1$ and $q_2 < q_1$.

the community tends to take incentives; when $y < y^*$, the probability of the community taking incentive measures gradually decreases, and the community gradually tends not to take incentive measures. The evolutionary game system of the two sides converges to point A (0,0). The stable strategy of the evolutionary game system is that the community does not take incentive measures and volunteers do not actively participate in community service $A(0,0)$.

(4) When $M_1 > N_1$ and $q_2 > q_1$. There are five equilibrium solutions in the dynamic replication equation system between two organization members: $A(0,0), B(1,0), C(1,1), D(0,1)$, and $E(x^*, y^*)$. The stability analysis results of these five equilibrium points are shown in Table 6:

$$J = \begin{bmatrix} \dfrac{\partial F(x)}{\partial x} & \dfrac{\partial F(x)}{\partial y} \\ \dfrac{\partial F(y)}{\partial x} & \dfrac{\partial F(y)}{\partial y} \end{bmatrix} = \begin{bmatrix} (1-2x)(yM_1 - N_1) & x(1-x)M_1 \\ y(1-y)kq_2 & (1-2y)k(xq_2 - q_1) \end{bmatrix}, \tag{14}$$

$$\begin{aligned} \mathrm{Det}(J) &= \frac{\partial F(x)}{\partial x}\frac{\partial F(y)}{\partial y} - \frac{\partial F(x)}{\partial y}\frac{\partial F(y)}{\partial x} \\ &= (1-2x)(yM_1 - N_1)(1-2y) \\ &\quad k(xq_2 - q_1) - x(1-x)M_1 y(1-y)kq_2, \end{aligned} \tag{15}$$

$$\begin{aligned} \mathrm{Tr}(J) &= \frac{\partial F(x)}{\partial x} - \frac{\partial F(y)}{\partial y} \\ &= (1-2x)(yM_1 - N_1) - (1-2y)k(xq_2 - q_1). \end{aligned} \tag{16}$$

As shown in Figure 4, the equilibrium strategy of the community and volunteer evolutionary game system has two points: $A(0,0)$ and $E(x^*, y^*)$. The choice of strategies of both sides depends not only on the initial probability of strategy choice but also on (x^*, y^*). The evolutionary game process is shown in Figure 4. In the regional DABE, the evolutionary game system of both sides converges to $A(0,0)$. The stable strategy of the evolutionary game is that the community does not take incentive measures and the volunteers do not actively participate in community services . In the regional DEBC, the evolutionary game system of both sides converges to $C(1,1)$. The stable strategy of the evolutionary game takes incentives for the community and volunteers actively participate in the communityservices). We use area to express the probability that the community will take incentive measures and volunteers will actively participate in community services. When x^* and y^* become smaller and smaller, S_{DABE} will become smaller and smaller, S_{DEBC} will become larger and larger, and the probability that the community will take incentive measures and volunteers will actively participate in community services will increase, and then the stable point will converge to $C(1,1)$. On the contrary, when x^* and y^* become larger, S_{DABE} will become larger but S_{DEBC} will become smaller, and then the stable point will converge to $A(0,0)$.

4. Example Analysis

The abovementioned analysis results show that the saddle point and stable equilibrium point are affected by the change of initial value and relevant parameters. This section will conduct numerical simulation to analyze the behavior of communities and volunteers in the epidemic prevention and control process under the influence of relevant factors. We set the initial parameters, as shown in Table 7, and analyze the impact on the member balance strategy in terms of the probability that the community is a high-risk community, the input of community incentive volunteers, the degree of active participation of volunteers, the unit cost of volunteers' participation in services, the unit benefit of the community receiving volunteer services, the probability of community selection incentive, and the probability of volunteers' active participation in services.

According to the assignment of each variable in Table 7, we make use of the replication evolutionary game equation system to draw a phase diagram, as shown in Figure 5. Simulation found that in a specific asymmetric 2 by 2 (2-player and 2-strategy) game, there is a phenomenon of multiple strategies coexisting. The stability

Table 6: Stability analysis of equilibrium point when $M_1 > N_1$ and $q_2 > q_1$

Equilibrium point	Det (J)		$Tr(J)$		Stability
$A(0,0)$	$N_1 k q_1$	+	$-(N_1 + k q_1)$	−	ESS
$B(1,0)$	$N_1 k(q_2 - q_1)$	+	$N_1 + k(q_2 - q_1)$	+	Unstable saddle point
$C(1,1)$	$(N_1 - M_1)k(q_1 - q_2)$	+	$(N_1 - M_1) + k(q_1 - q_2)$	−	ESS
$D(0,1)$	$(M_1 - N_1)k q_1$	+	$(M_1 - N_1) + k q_1$	+	Unstable saddle point
$E(x^*, y^*)$	$-(k^3 N_1 q_1 M_1 q_2 (M_1 - N_1)(q_2 - q_1)/(M_1 k q_2)^2)$	−	0	Indeterminacy	Unstable saddle point

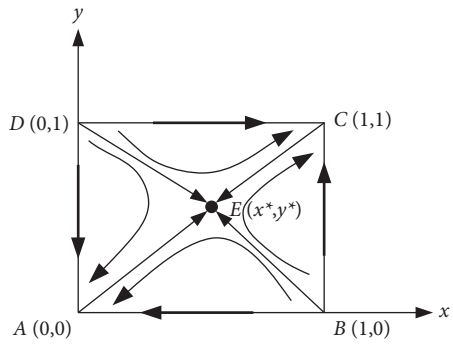

Figure 4: Stability strategy of evolutionary game system when $M_1 > N_1$ and $q_2 > q_1$.

Table 7: Initial values of relevant variables.

Variable	c	p	q_1	k	l_1	q_2	l_2	y	x
Numerical value	0.1	0.4	0.8	0.9	0.2	0.2	0.8	0.9	0.2

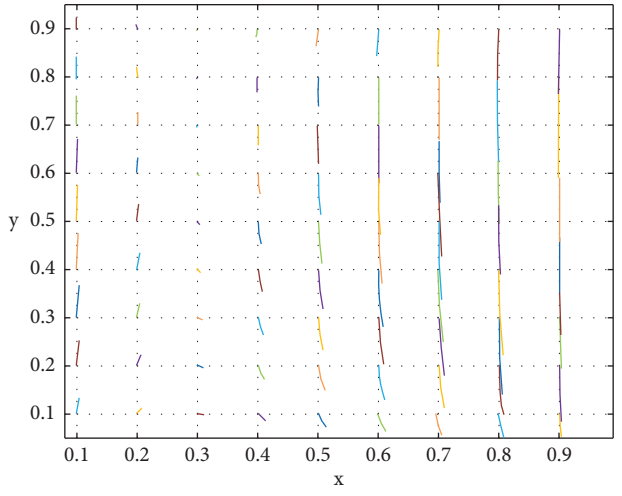

Figure 5: The phase diagram of dynamic game between community and volunteers.

strategy within the game does not always exist, and ESS depends on the initial probability of community and volunteer strategy investment. From the graph, it can be seen that (x^*, y^*) divides the graph into four regions. In their respective regions, over time, the game between the two groups will eventually tend to be stable. But from the entire evolution process, the final stable trend depends on x^* and y^*.

4.1. Impact of Community Risk Degree. To explore the impact of community risk on community and volunteer behavior, the evolutionary game process is analyzed by increasing the value of p, as shown in Figure 6. If the risk level of the community is low, the probability of the community not taking incentives and volunteers not actively providing services will increase over time. This is because when the risk in the community is low, the community does not need to invest too much in risk prevention, and without incentives, the enthusiasm of volunteer service investment is also damaged. When the incentive measures increase to a certain extent, the saddle point $E(x^*, y^*)$ gradually increases, and the stable equilibrium point finally converges to $A(1,1)$ which indicates that with the increase of the community risk level, the community is more inclined to take incentive measures, and volunteers are more inclined to actively participate in community services, so the community risk level is positively related to the positive behavior of members. This is because when community risks are high, the community actively invests costs to motivate volunteers and increase service investment in order to prevent risks.

4.2. Impact of Volunteers' Active Involvement. In order to explore the impact of volunteers' active involvement on the community and volunteers' behavior, the evolutionary game process is analyzed by increasing the value of q_1, as shown in Figure 7. If the level of active participation of volunteers is low, the probability of community not taking incentives and volunteers not actively providing services will increase over time. When the degree of active participation of volunteers increases to a certain extent, the saddle point $E(x^*, y^*)$ gradually decreases, and the stable equilibrium point finally converges to $A\ (1,0)$, which indicates that with the increase of the degree of active participation of volunteers, the community is more inclined to take incentive measures, and volunteers are more inclined to participate in community services in an inactive way. Therefore, the degree of active participation of volunteers is positively related to the community incentive strategy, and negatively related to the positive behavior of volunteers.

4.3. Impact of Volunteers' Inactivity. To explore the impact of volunteers' inactive involvement on the community and volunteers' behavior, the evolutionary game process is analyzed by increasing the value of q_2, as shown in Figure 8. If the volunteers are not actively engaged, the probability that the community will not take incentives and the volunteers will not actively provide services will increase over time. When the degree of active participation of volunteers

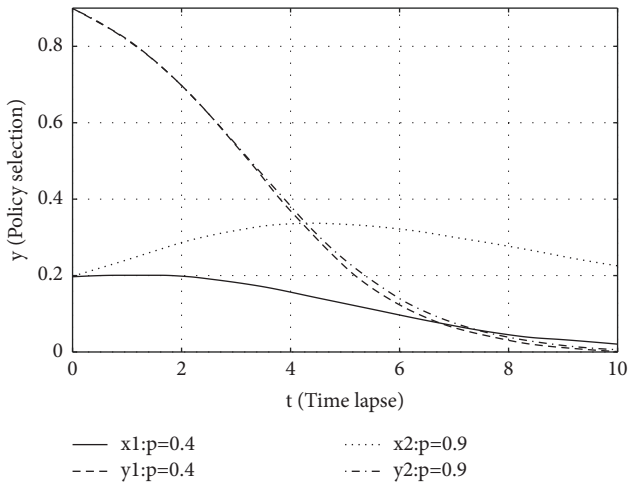

Figure 6: Impact of community risk level on evolution strategy.

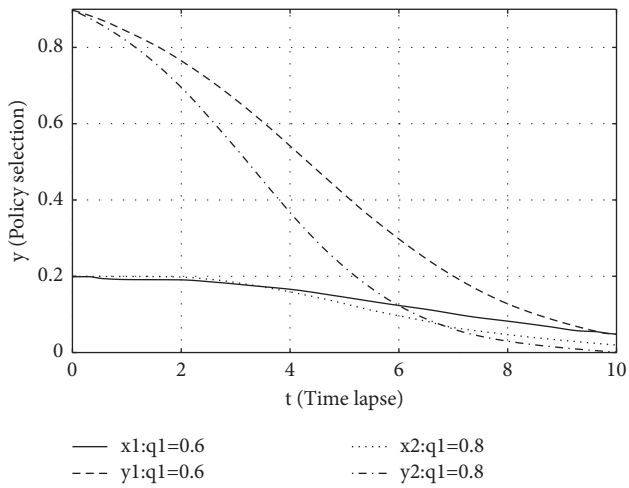

Figure 7: The impact of volunteers' active involvement on evolutionary strategies.

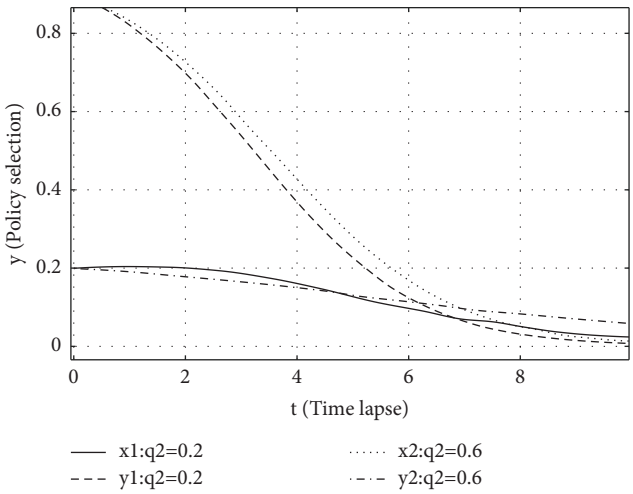

Figure 8: The impact of volunteers' inactive involvement on evolutionary strategies.

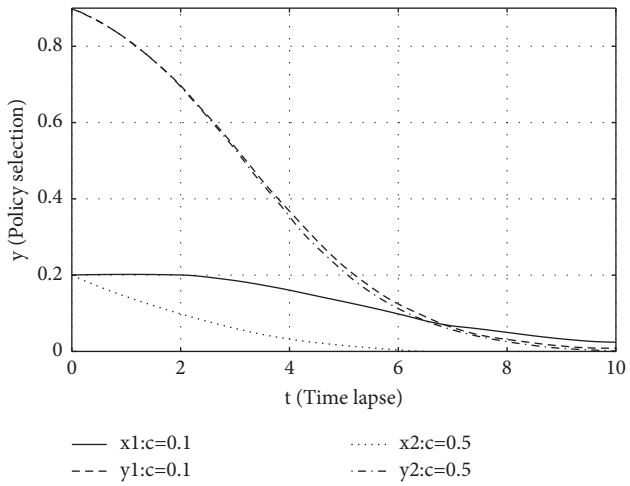

Figure 9: The impact of community incentives on evolutionary strategies.

increases to a certain extent, the saddle point $E(x^*, y^*)$ gradually decreases, and the stable equilibrium point finally converges to $A\ (0, 1)$, which indicates that with the increase of the degree of passive participation of volunteers, the community is more inclined to not take incentives, and volunteers are more inclined to actively participate in community services, so the degree of passive participation of volunteers is negatively related to the behavior of the community to take incentives. It is positively related to volunteers' active participation in community behavior.

4.4. Impact of Community Incentives. To explore the impact of community incentives on community and volunteer behavior, the evolutionary game process is analyzed by increasing the value of c, as shown in Figure 9. If the level of community incentive investment is low, the probability that the community will not take incentive measures and volunteers will not actively provide services will increase over time. When the degree of active participation of volunteers increases to a certain extent, the saddle point $E(x^*, y^*)$ gradually decreases, and the stable equilibrium point finally converges to $A\ (0, 1)$, which indicates that with the increase of the degree of community incentives, the community is more inclined to not take incentives, and volunteers are more inclined to actively participate in community services. Therefore, the degree of community incentives is negatively related to the behavior of the community to take incentives and positively related to the active participation of volunteers in community behavior.

5. Conclusions and Suggestions

This paper analyzes the equilibrium game between the community incentive level and the volunteer service input by constructing the "community-emergency volunteer" evolutionary game model, discusses the evolutionary

stability strategy of each subject, and roughly draws the evolutionary stage diagram and numerical simulation of each game subject by solving the dynamic equation. We analyzed the unique evolutionary stability strategy of the game model, and finally reached the following conclusions:

First, from the perspective of impact degree of community analysis, with the increase of community risk degree, the community is more inclined to take incentive measures, and volunteers are more inclined to actively participate in community services, so the risk degree of the community is positively related to the positive behavior of members. From the perspective of active involvement of emergency volunteers, with the increase of active involvement of volunteers, the community is more inclined to take incentive measures, and volunteers are more inclined to participate in community services less actively. Therefore, the degree of active involvement of volunteers is positively related to the community incentive strategy, and negatively related to the positive behavior of volunteers. With the increase of volunteers' inactive participation, the community is more inclined to not take incentive measures, and volunteers are more inclined to actively participate in community services. Therefore, the degree of volunteers' inactive participation is negatively related to the community's behavior of taking incentive measures, and is positively related to volunteers' active participation in community activities. From the perspective of the impact of community incentives, with the increase of community incentives, the community is more inclined to not take incentives, and volunteers are more inclined to actively participate in community services. Therefore, the degree of community incentives is negatively related to the behavior of the community to take incentives, and positively related to the behavior of volunteers actively participating in the community.

Second, the level of incentives and incentives in the community depend on the cost and participation of volunteers. This process is a two-way game process. When the cost is too high and the incentive measures are inappropriate, even if the community increases the incentive level, it is difficult for volunteers to continue to improve their enthusiasm for participation. Therefore, research or reference should be made in advance before selecting incentive measures to effectively improve the enthusiasm of emergency volunteers within a reasonable cost range.

Third, community incentives are two-sided. In the process of incentive, we should grasp the reasonable interval and degree to avoid transitional incentive. Transitional incentives will form a "rightful" concept for emergency volunteers, which will lead to the gradual reduction of incentive flexibility, the rising cost of incentives, the gradual reduction of enthusiasm of emergency volunteers, and the accumulation of dissatisfaction with the community, which is not conducive to the long-term development of the community.

Based on the abovementioned conclusions, this paper puts forward three suggestions to improve the synergy between community and volunteer service input. First, the community should actively establish a reasonable "incentive-guarantee" mechanism. In practical work, the community often adopts the policy of "praising the small part and motivating the large part," and should continue to implement incentive policies such as commendation so that volunteers can be widely recognized by the society and feel a sense of achievement and belonging; second, strengthen the training of emergency volunteers. Strengthen the training of community emergency volunteers on a daily basis. Emergency volunteers are different from other volunteers, that is, they are required to respond quickly and actively in the face of emergencies, which require excellent technical skills to reduce the time for training after the event; third, to guarantee emergency volunteers with institutional norms. The community will provide certain material support while ensuring spiritual incentives, and fully support and respect volunteers. When an emergency comes, the community should actively do a good job of logistics support for emergency volunteers and solve the worries for volunteers, so that the volunteer community can concentrate on community volunteer services [30].

Data Availability

The data used to support the findings of this study are from public databases.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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