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Tripartite Evolutionary Game and Policy Simulation: Strategic Governance in the Redevelopment of the Urban Village in Guangzhou

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Abstract: The scarcity of land drives urban village redevelopment projects, which involve interest redistribution among stakeholders with distinct demands. This paper utilizes evolutionary game theory and simulation methods, constructing a tripartite game model under the institutional arrangement of bottom-up with private developer funding. This study identifies the stable strategies and evolutionary trends of the tripartite interactions under four distinct scenarios and validates these strategies through simulations. The redevelopment of XC village validates the assumptions of the model and theoretical analysis, suggesting that when private developers adopt forced demolition strategies, although villagers ultimately choose to sign the contract of property exchange, it can easily lead to social conflicts. These research findings can enlighten the government to form a tripartite alliance to smooth urban village redevelopment.

Keywords: urban village redevelopment; stakeholders; tripartite evolutionary game; equilibrium strategy; policy simulation



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1. Introduction

Since the 1980s, a number of villages in China have been incorporated into urban planning areas, one after another [1]. In order to reduce the costs of compensation and transaction, the Chinese government adopted a land expropriation method by first expropriating farmlands [2]. Thus, the remaining rural land built up for settlement and reserved commercial land are surrounded by rapidly expanding cities [3]. Under the urban–rural land system, the informal concept of urban villages consequently emerged, named chengzhongcun in Chinese [4,5]. Urban villages are often seen as rural enclaves within the city, retaining traditional village management, customs, and social networks [6].

However, China’s urban villages are subject to a dual land ownership system [7], whereby urban land is state-owned and rural land is collectively-owned. As urban villages lack the legal status of urban land, they also lack public services that should be provided by the government. China’s urban villages are seen as a kind of “cheap urban space”, taking on the role of urban slums in other developing countries [3]. Thus, in urban sociology, urban villages in China are viewed as chaotic physical spaces associated with urban problems such as disorganized land use and insufficient infrastructure, ultimately slated for redevelopment in the urbanization process [1,8]. As a crucial element of urban renewal, the redevelopment of urban villages involves reorganizing and restructuring various spatial elements [9]. The modernization process promotes stability but can also breed instability [10]. Redeveloping urban villages entails redefining property rights

between rural and urban land ownership [11] and reorganizing the social networks of stakeholders [12]. This transformation often involves social conflict risks [13]. Mishandling those risks can lead to social instability, often demonstrated by demonstrations, protests, collective petitions, and violent clashes [14,15]. The Social Blue Book published by the Chinese Academy of Social Sciences in 2013 pointed out that there were tens of thousands of group incidents arising from various social conflicts. Social group incidents are mainly conflicts over land acquisition and relocation, environmental pollution, and labor disputes, with group incidents triggered by land acquisition and relocation accounting for about 50% of all social group incidents. In 2014, the Report on the Development of the Rule of Law in China, published by the Institute of Law of the Chinese Academy of Social Sciences, pointed out that there were numerous reasons for group incidents involving more than 100 people, with labor disputes, improper law enforcement, and land demolition and requisition at the top of the list. Group incidents involving land demolition and requisition accounted for 11.14% of the research sample. In response to potential social conflict risks, the 14th Five-Year Plan and the 20th National Congress report in China emphasize the need to build a comprehensive mechanism for managing social conflicts. Therefore, addressing the conflicts induced by urban village redevelopment is of significant practical importance [13].

Previous research has systematically explored urban village redevelopment conflicts from various perspectives. From the social network analysis perspective, local governments are the most critical stakeholders in determining the final effect of social risks during housing demolition [13]. From the neo-institutional economics perspective, the institutional arrangement can impact the project duration and conflict levels during the urban village redevelopment process [4,16]. The institutional paradigm perspective argues that the fundamental cause of land acquisition conflicts is the unclear definition of property rights [17]. However, this perspective overlooks the behavioral choices of individual stakeholders. The place attachment theory suggests that villagers' strong attachment to their homeland and kinship consciousness towards family clans make them prone to collective petitions and even collective incidents due to dissatisfaction with land acquisition [18]. However, this applies only to urban villages with strong clan network relationships, and this perspective neglects the impact of institutional arrangements on redevelopment outcomes. In addition to the government and individual villagers in the redevelopment of urban villages, private developers are also an important role that cannot be ignored. In terms of transaction costs theory, the institutional change from state-dominated to market-oriented urban redevelopment has greatly facilitated redevelopment activities [19]. The introduction of market-oriented institutions in urban redevelopment reduces transaction costs and improves the efficiency of urban redevelopment in densely built-up areas with fragmented ownership by stimulating the participation of market players (e.g., private developers) [20]. For example, Hong Kong introduced the Land Compulsory Sale Redevelopment Ordinance in 1998 to create an incentive scheme for private participation in urban redevelopment [21] and the 1999 Strata Title Act was officially launched in Singapore to facilitate the collective sale of old properties for redevelopment [22], both of which have substantially reduced the transaction costs of land assembly.

It is noteworthy that social stability incidents related to urban village redevelopment are predominantly examined through qualitative studies, such as case studies [17,23], ethnographic studies [24], and content analyses [25]. In recent years, quantitative methods have also been increasingly employed. Some scholars have identified factors influencing conflict levels during the urban village redevelopment process using ordered logit regression [26]. Game theory has been used to quantify stakeholder conflicts in urban redevelopment projects [27]. The land expropriation involved in the redevelopment of urban villages is a process of interest redistribution, which essentially applies to the game analysis between decision-making subjects [28]. The authors from this field often argue that social disputes arise from the unbalanced benefit distribution among interest stakeholders [29,30]. Due to unbalanced benefit redistribution, villagers often feel unfairly treated and dissatisfied with compensation, leading to group confrontations and violent conflicts [31]. Some scholars ar-

gue that a failure to engage with villagers adequately can lead to resistance against housing demolition [32]. If all stakeholders can benefit from the redevelopment, a “collaborative partnership” will form, which is critical to smooth project implementation [11].

However, the limitations of existing game theory studies are mainly twofold: firstly, most studies focus on pairwise interactions [33,34], such as studying the evolutionary game model between both farmers and local governments [35] and the gaming behaviors of inspectors and developers [36]. Fewer studies have focused on tripartite interactions [29]. The redevelopment of an urban village is a complex system project involving multiple stakeholders [26]. An evolutionary game model considering only two subjects is the most basic situation, but it cannot explain the complexity of reality well. With three major decision-making bodies, any two sides of the game cannot, in fact, ignore the remaining side of the impact of their decisions. Secondly, some studies have considered a third stakeholder, but such issues are usually regarded as static and assume that the interested parties are perfectly rational; for example, one study has applied the static game of Nash equilibrium to investigate the bargaining process between developers and residents concerning benefit distribution and considering the government’s role in achieving, through various regulatory strategies, the goals of either fairness or efficiency [30]. In reality, however, on the one hand, market conditions and participant behaviors tend to change dynamically, so staticity may not accurately reflect these changes. On the other hand, participants often do not have access to all the information relevant to the game, and their lack of information may lead to participants’ inability to make optimal decisions.

Different from the traditional game model, the tripartite evolutionary game model originates from the theory of biological evolution of superiority and inferiority, which believes that individuals in reality are rational and bounded [37]. When studying the interaction of multiple parties, the evolutionary game method can intuitively reflect the decision-making process of the parties in different situations, presenting the dynamic process of reaching system equilibrium [38]. It is reasonable to take the evolutionary game theory as the game theory of this paper for the following reasons: firstly, in the implementation process of an urban village redevelopment project, the government, developers, and villagers are not completely rational; in other words, they cannot obtain all the information necessary to make a perfect decision, and they can only make a decision based on limited information. Secondly, the strategies adopted by the government, developers, and villagers are not static. They will dynamically adjust their strategies according to the strategies of other participants. The replicated dynamic equations in evolutionary game theory can simulate the evolution process of different strategies. Finally, the selection and optimization of strategies by the government, developers, and villagers is a dynamic process. In this process, due to the complexity of the interactions among the participants of the three-party game, their strategy choices will affect each other and change over time, gradually forming a stable strategy, which can be realized by evolutionary game theory.

As mentioned above, evolutionary game theory is an effective method to analyze the strategic interaction among three or more parties [39]. The redevelopment of urban villages is a complex systematic project involving multiple decision-makers: local governments, private developers, and local villagers [26]. Their behavioral strategies show diversity and complexity, and the dynamic evolution of a strategic equilibrium is influenced by a variety of factors [35]. The government can enhance the motivation of private developers and local villagers by formulating effective land development policies as well as regulatory mechanisms [40]. For private developers, land development can provide them with idle residential land use rights and economic profits, etc., while also bearing the purchase cost of residential land use rights as well as operating costs [41]. When considering whether the villagers agree to sign a contract for demolition and relocation, the economic compensation fee, the increase in their cost of living, and the cost and risk of cooperation, etc., are crucial considerations [27]. Only by dealing with the inherent relationships between these three subjects of interest and finding a tripartite equilibrium strategy can these participants be encouraged to actively promote the redevelopment of urban villages and the process of urbanization in China.

Therefore, this paper employs evolutionary game theory to analyze the interest demands and bargaining relationships of the three primary stakeholders in urban village redevelopment: local governments, private developers, and villagers, which represent the state, market, and society, respectively. It aims to propose equilibrium strategies to resolve conflicts of interest among these stakeholders. By applying evolutionary game theory, this study broadens the scope of its application in the social sciences and offers new insights and perspectives for understanding the conflict dynamics in urban village redevelopment. Furthermore, elucidating the bargaining relationships among the three key stakeholders in the redevelopment process not only facilitates better coordination and understanding of their interests to achieve mutually beneficial outcomes but also provides policy recommendations for the government to effectively advance urban village redevelopment projects.

2. Tripartite Evolutionary Game Model and Analysis

2.1. Basic Assumptions

Some scholars categorize the institutional arrangements of urban village redevelopment into four types: top-down with government funding, top-down with villager funding, bottom-up with villager funding, and bottom-up with private developer funding [42]. This paper analyzes urban village redevelopment based on a bottom-up approach with private developer funding. Since private developers are one of the main subjects of this analysis, this will be referred to simply as the bottom-up arrangement. In this model, private developers actively participate in the formulation and negotiation of resettlement compensation policies, engaging in a game relationship with villagers, while the local government primarily plays a supervisory role. Based on this, the following assumptions are proposed:

Assumption 1: In evolutionary games, individuals are usually assumed to be finitely rational, which means that they may not fully consider all possible strategies and outcomes when making decisions, but instead rely on heuristic rules or mimicry behavior [39]. The players in the evolutionary game in this paper are local governments, private developers, and villagers, and the individuals in these groups are all bounded rational. This means that individual decision-making cannot quickly reach optimality but gradually achieves optimal strategies through dynamic processes such as imitation and learning. The core idea of the imitator dynamic is that individuals observe the behavior of other individuals in a group and adapt their strategies based on these observations. This imitative behavior can be based on direct observation or on indirect information, such as an individual's fitness or success. The imitator dynamic usually assumes that individuals are more inclined to imitate strategies that perform better in a group because they are perceived to be more likely to lead to success. It has been found that when a developer can gain considerable profit by hoarding land, which can be easily imitated by other developers, the proportion of developers choosing a hoarding strategy will gradually increase [36]. Illegal land acquisition is still possible due to the profit motive [43], and developers' illegal demolition and relocation procedures will also be imitated by other developers. "Nail households" refuse to be demolished and relocated because of 'unfair compensation' or in order to obtain higher financial compensation [44], and this behavior can be imitated by other villagers. Similarly, for the government, good regulation ensures that legitimate eviction and demolition procedures can win the praise of the people and financial revenue [40], which will be learned to be imitated.

Assumption 2: Although evolutionary game theory starts from individual behavioral strategy choices, the study subjects are groups. In analyzing dynamic evolution, groups exhibit both behavioral choices and behavioral mutations. Evolutionary games explain how groups reach equilibrium states. The subjects of this study are the three following groups: local governments, private developers, and villagers. Evolutionary game models consider the effects of interactions and structure within a group on strategy evolution. For example, individuals may adjust their strategies based on interactions with specific neighbors, or

the spread of strategies may be influenced by the structure of the group. In an early stage, villagers refused to sign with the developer because the compensation for demolition and relocation did not meet their ideal expectations, but in the later stage, when they saw that other villagers had received additional benefits other than the compensation fee, they would choose to cooperate [40]. Over time and with continuous learning to imitate, the strategic outcome of the game stabilizes. The concept of an evolutionarily stable strategy (ESS) for three-way games refers to the fact that once a certain distribution of strategies is formed via natural selection and group dynamics, this distribution is unlikely to change due to small perturbations, i.e., the distribution of strategies is stable in the group. In other words, once the three groups, local government, private developers, and villagers, form a stable strategy, they will not be easily perturbed.

Assumption 3: The three groups—local governments, developers, and villagers—are in different positions and have asymmetric information, making the game between them an asymmetric one. It is further assumed that local governments have two strategies: supervision and non-supervision; developers have two strategies: legal demolition and forcible demolition (illegal demolition); and villagers have two strategies: agreement and resistance. Forcible demolition involves the use of coercive tactics, such as cutting off utilities or employing violent means to compel villagers to move. According to the “Regulations on the Expropriation and Compensation of Houses on State-owned Land” issued by the State Council of China, any forced evictions executed by administrative bodies on households that refuse to relocate within the stipulated period must be sanctioned by a court. Consequently, developers’ actions of forcing villagers to relocate through forcible eviction are illegal both in terms of authority and procedure. In this study, forcible demolition is also defined as illegal demolition. “Supervision” refers to the effective regulation by local governments to standardize developers’ land expropriation practices, while “non-supervision” denotes the failure of local governments to employ effective administrative measures to curb illegal land expropriation activities such as forcible demolition by developers. “Agreement” refers to villagers consenting to sign the contract of property exchange, whereas “resistance” refers to villagers refusing to sign the agreement and resisting the urban village’s redevelopment.

2.2. Benefit Analysis and Parameter Descriptions

The local government acts as both a decision-maker and supervisor in the urban village redevelopment process [40]. Redevelopment can enhance a city’s appearance and land utilization efficiency. The local government can gain social benefits from urban village redevelopment, including economic growth, the optimization of the city’s spatial structure, environmental improvement, and crime reduction [45,46]. Therefore, this paper assumes that the social utility generated by the government from the redevelopment of urban villages is U . On the contrary, if the government fails to achieve the redevelopment goal, it will bear a certain opportunity cost, C_1 . At the same time, the government is a regulator in the urban village renewal program. For example, China’s State Council promulgated the “Regulations on the Expropriation and Compensation of Houses on State-owned Land”, which require local governments to strengthen the supervision and inspection of the implementation of policies and regulations on land expropriation, demolition, and relocation. China’s Ministry of Land and Resources requires relevant departments to strictly manage the prevention of illegal land acquisition. The government needs to bear the corresponding supervision costs when implementing the relevant supervision policies. The government supervision cost refers to the relevant costs incurred by government departments in the supervision of market players and engineering construction works; for example, the administrative costs of people, money, and materials incurred by the government for the need to set up specialized institutions and implement relevant policies and regulations. In addition, the government sends personnel to project sites for inspection, and other work will also occur on-site supervision costs [47]. Referring to the approach of scholars Li [29] and Hui [43], this paper assumes that the local government inspects and penalizes developers

for forced evictions, with a penalty of P and a supervision cost of S . In addition, if the local government fails to monitor the illegal behavior of developers and triggers social public opinion, it will damage the image of the government. For example, China Central Television (CCTV) has exposed the shady practices of the urban village redevelopment project in YJ Village, Guangzhou City, which affected social public opinion and damaged the government's image to a certain extent. Therefore, this paper assumes that the loss of the government's image caused by the government's failure to fulfill its responsibility of good supervision is recorded as L . Conversely, the enhancement of the government's image that will be achieved if the government supervises the developer's illegal behaviors, such as forced demolition, and achieves a better social response is recorded as R_1 .

A private developer's main goal is to profit from land development. After obtaining the right to use unused residential land at a lower land price, private developers can make considerable economic profits by redeveloping the land [41]. The 2021 interim results report of China's listed real estate companies showed that Kaisa Corporation's first-half operating revenue was 30.07 billion yuan, up 34.8 percent year-on-year. Times China Holdings Limited's first-half gross profit was about 4.548 billion yuan, with a gross profit margin of 33.3 percent. It can be seen that private developers participating in urban renewal projects can reap benefits. In this paper, it is assumed that the developer's return under a non-compulsory demolition strategy is R_2 and the return under a compulsory demolition strategy is R_3 . At the same time, the real estate enterprises in the development of the process of the various fees cannot be ignored, as this will produce the development cost of the project. Therefore, it is assumed that the development cost under the developer's legal demolition strategy is C_2 and the development cost under the illegal demolition strategy is C_3 . In 2015, a developer in Shanghai demolished a century-old residential house without authorization and was fined 80,000 RMB by the government authorities, which indicates that a developer's illegal behavior may face the risk of being punished by the government. Therefore, if the private developers adopt a forced demolition strategy and are investigated by the local government's supervision, they will then need to bear two additional costs: the penalty cost (P) from government supervision and the compensation cost (C) to villagers upon government investigation. Additionally, if villagers refuse to sign the contract, halting the redevelopment, the private developer will bear the sunk cost of preliminary engineering and opportunity costs due to construction delays, which is denoted as C_0 in this paper. For example, the company responsible for the redevelopment of XC village in Guangzhou City lost a huge amount of money because the project was delayed for too long, which led to the depletion of funds, and they declared bankruptcy.

Villagers are the largest stakeholders in the urban village redevelopment process. According to data released by Guangzhou City in 2019, the migrant worker population in Guangzhou's urban villages accounts for about 35% of the city's population, and most of Guangzhou's rental housing is in urban villages. Therefore, local villagers who own houses in urban villages can earn a sizable income by renting them out. For example, the monthly rent for a house in an urban village in the center of Guangzhou ranges from 1000 to 5000 yuan. The annual income from rentals in SP villages situated in the center of Guangzhou City exceeds hundreds of millions of RMB, making it a major source of income for the local villagers. If the local villagers agree to sign the contract, then they can obtain the corresponding benefits, such as improved living conditions, demolition and relocation compensation, and temporary relocation fees [48]. In the case of XC village, the government implemented the compensation program of "demolish one and compensate one" for the local villagers who agreed to sign the contract for demolition and relocation, and in addition, the materials of balconies were compensated for at the rate of 2000 RMB/m². However, the local villagers also have to bear the costs of the loss of their right to use the house, potential economic risks, increased cost of living, and the costs and risks of cooperation brought about by the redevelopment [49]. If the villagers do not agree to sign up to become "nail households", they can gain from housing rental and other aspects, but they will also lose the opportunity to improve living conditions and other opportunities, as well as may face

the situation of multiple games with the private developers. Therefore, this paper assumes that the villagers' benefit when the developer adopts the non-forced demolition strategy is R_4 and the cost under the villagers' signing strategy is C_4 ; the villagers' benefit when the developer adopts the forced demolition strategy is R_5 and the cost under the villagers' non-signing strategy is C_5 .

Based on the analysis above, the parameters are defined as shown in Table 1.

Table 1. Parameter definition.

Stakeholders	Symbols	Descriptions
Local government	S	The cost incurred in supervising the private developer's actions
	U	The social benefits derived from urban village redevelopment, including economic growth, urban space optimization, environmental improvement, and security enhancement
	C_1	The opportunity cost of not achieving the redevelopment goals
	R_1	The improvement in government image brought by supervising the private developer's behavior
	L	The loss in government image was caused by not supervising the private developer and the private developer taking forced demolition
Private developers	R_2	Revenue from adopting a non-forced demolition strategy
	R_3	Revenue from adopting a forced demolition strategy
	C_2	Development cost under a non-forced demolition strategy
	C_3	Development cost under a forced demolition strategy
	P	Penalty imposed by the local government for adopting a forced demolition strategy
	C	The amount of compensation provided to villagers when private developers adopt forced demolition strategy under government supervision
	C_0	Sunk costs of preliminary engineering, along with actual and opportunity costs due to project delays
Villagers	R_4	Revenue received when the private developer adopts a non-forced demolition strategy
	R_5	Revenue received when the private developer adopts a forced demolition strategy
	C_4	Cost incurred under the signing contract
	C_5	Cost incurred under the non-signing contract

Note: All the above parameters are greater than 0, and $R_2 > C_2$, $R_3 > C_3$, $R_4 > C_4$, $R_5 > C_4$.

According to the hypothesis, it can be seen that the local government, private developers, and villagers are all finite rational and can achieve an evolutionary steady state of urban village redevelopment through autonomous learning [29,30,36,43].

Local government is known to have two strategies: supervision and non-supervision. This is denoted as $S_1 = (\text{supervision, non-supervision})$, and the probabilities of choosing these two strategies are x and $1 - x$, $x \in (0, 1)$. When the urban village redevelopment project is successfully implemented, the social utility that the government can generate from it is denoted as U . In this case, if the government adopts a supervision strategy, the image enhancement that can be brought to the government is R_1 and the regulatory cost that needs to be borne by the government is S , so the government's benefit is $R_1 - S + U$. Of course, if the private developer adopts the illegal demolition strategy, it will also be penalized by the local government's regulation, and the government's payoff at this time is $R_1 - S + U + P$. On the other hand, if the government implements a non-supervision strategy and the private developer adopts an illegal demolition strategy, it will also bring the government an image loss, and the government's benefit will be $U - L$. Similarly, if the urban renewal project is firmly resisted by the villagers and fails, the local government

does not derive a social utility (U) and incurs an opportunity cost (C_1). In this case, if the government adopts a supervision strategy, the government's payoff becomes $R_1 - S - C_1$ (when the private developer adopts a legal demolition strategy) and $R_1 - S - C_1 + P$ (when the developer adopts an illegal demolition strategy). If the government adopts a non-supervision strategy, the government's payoff becomes $-C_1$ (when the private developer adopts a legal demolition strategy) and $-C_1 - L$ (when the developer adopts an illegal demolition strategy).

Private developers are known to have two strategies: legal demolition and illegal demolition. This is denoted as $S_2 = (\text{legal demolition, illegal demolition})$, and the probabilities of choosing these two strategies are y and $1 - y$, $y \in (0, 1)$. Under the premise that the villagers cooperate with the signing of the contract, the private developers can gain revenue from the urban village redevelopment project after it is successfully implemented. In this case, if the private developer adopts a legal demolition strategy, the developer's payoff is $R_2 - C_2$; however, if the private developer adopts an illegal demolition strategy and is regulated and penalized by the government, the developer's payoff at this time is $R_3 - C_3 - P - C$; and if the private developer adopts an illegal demolition strategy but is not regulated by the government, the private developer's payoff is $R_3 - C_3$. If the urban village redevelopment project ends in failure, the private developer not only does not get any revenue from the project, but also pays the sunk cost, delay cost, and opportunity cost (C_0) for it, so the developer's benefit is $-C_0$. In particular, if the developer adopts forced demolition and is regulated and penalized by the government, the developer's benefit is $-P - C_0$.

Villagers are known to have two strategies: agreement and resistance. This is denoted as $S_3 = (\text{agreement, resistance})$, and the probabilities of choosing these two strategies are z and $1 - z$, $z \in (0, 1)$. On the premise that the local villagers agree to sign and cooperate with the implementation of the urban village redevelopment project, if the private developer adopts a legal demolition strategy, the villagers' benefits are $R_4 - C_4$. However, if the private developer adopts an illegal demolition strategy, then the villagers' benefits are $R_5 - C_4$. If the developer's illegal demolition is supervised and punished by the local government, then the villagers' benefits are $R_5 - C_4 + C$. On the contrary, once the villagers adopt a resistance strategy and the project cannot be successfully implemented, the villagers have to bear the cost, at which time their benefit is $-C_5$.

Table 2 presents the payoff matrix for the evolutionary game involving the local government, private developers, and villagers.

Table 2. The payoff matrix of local government, private developers, and villagers.

	Villagers	Local Government	
		Supervision (x)	Non-Supervision ($1 - x$)
Private Developers Legal demolition (y)	Agreement (z)	$(R_1 - S + U, R_2 - C_2, R_4 - C_4)$	$(U, R_2 - C_2, R_4 - C_4)$
	Resistance ($1 - z$)	$(R_1 - S - C_1, -C_0, -C_5)$	$(-C_1, -C_0, -C_5)$
Private Developers Illegal demolition ($1 - y$)	Agreement (z)	$(R_1 - S + U + P, R_3 - C_3 - P - C, R_5 - C_4 + C)$	$(U - L, R_3 - C_3, R_5 - C_4)$
	Resistance ($1 - z$)	$(R_1 - S - C_1 + P, -P - C_0, -C_5)$	$(-C_1 - L, -C_0, -C_5)$

Note: $0 < x < 1, 0 < y < 1, 0 < z < 1$.

Through the tripartite evolutionary game payoff matrix, we can further derive the expected and average payoffs of the local governments, private developers, and villagers. The expected payoffs for the local governments adopting the supervision strategy (U_{x1}) and the non-supervision strategy (U_{x2}), and the local governments' average payoff ($\bar{U}_x$), are as follows:

$$U_{x1} = yz(R_1 - S + U) + y(1 - z)(R_1 - S - C_1) + (1 - y)z(R_1 - S + U + P) + (1 - y)(1 - z)(R_1 - S - C_1 + P) = z(U + C_1) + (R_1 - S - C_1 + P) - yP$$

$$U_{x2} = yzU + y(1-z)(-C_1) + (1-y)z(U-L) + (1-y)(1-z)(-C_1-L) \\ = yL + [z(U+C_1) - C_1 - L]$$

$$\bar{U}_x = xU_{x1} + (1-x)U_{x2}$$

Similarly, the expected payoffs for the private developers adopting the legal demolition strategy (U_{y1}) and illegal demolition strategy (U_{y2}), and private developers' average payoff ($\bar{U}_y$), are as follows:

$$U_{y1} = xz(R_2 - C_2) + x(1-z)(-C_0) + (1-x)z(R_2 - C_2) - (1-x)(1-z)C_0 \\ = z(R_2 - C_2) - (1-z)C_0$$

$$U_{y2} = xz(R_3 - C_3 - P - C) + x(1-z)(-P - C_0) + (1-x)z(R_3 - C_3) + (1-x)(1-z)(-C_0) \\ = x(-zC - P) + z(R_3 - C_3 + C_0) - C_0$$

$$\bar{U}_y = yU_{y1} + (1-y)U_{y2}$$

The expected payoffs for the villagers accepting the redevelopment strategy (U_{z1}) and resisting the redevelopment strategy (U_{z2}), and villagers' average payoff ($\bar{U}_z$), are as follows:

$$U_{z1} = xy(R_4 - C_4) + x(1-y)(R_5 - C_4 + C) + (1-x)y(R_4 - C_4) + (1-x)(1-y)(R_5 - C_4) \\ = x(1-y)C + y(R_4 - R_5) + (R_5 - C_4)$$

$$U_{z2} = xy(-C_5) + x(1-y)(-C_5) + (1-x)y(-C_5) + (1-x)(1-y)(-C_5) = -C_5$$

$$\bar{U}_z = zU_{z1} + (1-z)U_{z2}$$

2.3. The Replicated Dynamic Equations of the Tripartite Game

According to the basic principles of replicator dynamics, the growth rate of a strategy is equal to its relative fitness. As long as the fitness of the strategy is higher than the average fitness, the proportion of the strategy will change over time. Thus, the replicated dynamic equations for the asymmetric evolutionary game among local authorities, private developers, and villagers are as follows:

Replicated dynamic equations for local governments are shown as follows:

$$F(x) = \frac{dx}{dt} = x(U_{x1} - \bar{U}_x) = x(1-x)(U_{x1} - U_{x2}) \\ = x(1-x)[R_1 - S + P + L - y(P+L)]$$

For convenience in calculation, let $y_0 = \frac{R_1 - S + P + L}{P + L}$

Setting $F(x) = 0$, we have the following two cases:

Case (1): If $1 - S + P + L - y(P+L) = 0$, i.e., $y = y_0$, $F(x)$ tends to zero infinitely and the game reaches a stable state regardless of the value of x .

Case (2): If y is not equal to y_0 , the solutions $x_1 = 0$ and $x_2 = 1$ are two stable states.

To ensure that the local authorities achieve an evolutionarily stable strategy, a necessary condition is $\frac{dF(x)}{dx} < 0$. Taking the derivative of $F(x)$, we get $\frac{dF(x)}{dx} = (1-2x)[R_1 - S + P + L - y(P+L)]$. Thus, analyzing the different scenarios for Case (2), when $R_1 - S + P + L - y(P+L) > 0$, $\frac{dF(x)}{dx}|_{x=0} > 0$ and $\frac{dF(x)}{dx}|_{x=1} < 0$, $x = 1$ is the equilibrium point, and local authorities are inclined to choose the supervision strategy. When $R_1 - S + P + L - y(P+L) < 0$, $\frac{dF(x)}{dx}|_{x=0} < 0$ and $\frac{dF(x)}{dx}|_{x=1} > 0$; hence, $x = 0$ is the equilibrium point and local authorities are inclined to choose the non-supervision strategy.

The replicated dynamic equation for private developers is shown as follows:

$$F(y) = \frac{dy}{dt} = y(U_{y1} - \bar{U}_y) = y(1-y)(U_{y1} - U_{y2}) \\ = y(1-y)[z(R_2 - C_2 - R_3 + C_3) + x(zC + P)]$$

For convenience in calculation, let $x_0 = \frac{z(-R_2 + C_2 + R_3 - C_3)}{zC + P}$

Setting $F(y) = 0$, we have the following two cases:

Case (1): If $z(R_2 - C_2 - R_3 + C_3) + x(zC + P) = 0$, i.e., $x = x_0$, $F(y)$ tends to zero infinitely, and the game reaches a stable state regardless of the value of y .

Case (2): If x is not equal to x_0 , the solutions $y_1 = 0$ and $y_2 = 1$ are two stable states.

To ensure that the private developers achieve an evolutionarily stable strategy, a necessary condition is $\frac{dF(y)}{dy} < 0$. Taking the derivative of $F(y)$, we get $\frac{dF(y)}{dy} = (1 - 2y)[z(R_2 - C_2 - R_3 + C_3) + x(zC + P)]$. Thus, analyzing the different scenarios for Case (2), when $z(R_2 - C_2 - R_3 + C_3) + x(zC + P) > 0$, $\frac{dF(y)}{dy}|_{y=0} > 0$ and $\frac{dF(y)}{dy}|_{y=1} < 0$, $y = 1$ is the equilibrium point, and private developers are inclined to choose the legal demolition strategy. When $z(R_2 - C_2 - R_3 + C_3) + x(zC + P) < 0$, $\frac{dF(y)}{dy}|_{y=0} < 0$ and $\frac{dF(y)}{dy}|_{y=1} > 0$, $y = 0$ is the equilibrium point, and private developers are inclined to choose the illegal demolition strategy.

Replicated dynamic equation for villagers are shown as follows:

$$\begin{aligned} F(z) &= \frac{dz}{dt} = z(U_{z1} - \bar{U}_z) = z(1 - z)(U_{z1} - U_{z2}) \\ &= z(1 - z)[x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5] \end{aligned}$$

For convenience in calculation, let $x_1 = \frac{yR_5 - R_4 - R_5 + C_4 - C_5}{C - yC}$

Setting $F(z) = 0$, we have the following two cases:

Case (1): If $x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5 = 0$, i.e., $x = x_1$, $F(z)$ tends to zero infinitely, and the game reaches a stable state regardless of the value of z .

Case (2): If x is not equal to x_1 , the solutions $z_1 = 0$ and $z_2 = 1$ are two stable states.

To ensure that the villagers achieve an evolutionarily stable strategy, a necessary condition is $\frac{dF(z)}{dz} < 0$. Taking the derivative of $F(z)$, we get $\frac{dF(z)}{dz} = (1 - 2z)[x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5]$. Thus, analyzing the different scenarios for Case (2). When $x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5 > 0$, $\frac{dF(z)}{dz}|_{z=0} > 0$ and $\frac{dF(z)}{dz}|_{z=1} < 0$, $z = 1$ is the equilibrium point, and villagers are inclined to accept the redevelopment. When $x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5 < 0$, $\frac{dF(z)}{dz}|_{z=0} < 0$ and $\frac{dF(z)}{dz}|_{z=1} > 0$, $z = 0$ is the equilibrium point, and villagers are inclined to resist the redevelopment.

2.4. Results of Tripartite Evolutionary Game

From the above analysis, the replicated dynamic system for the local government, private developers, and villagers is obtained:

$$\begin{cases} F(x) = \frac{dx}{dt} = x(1 - x)[R_1 - S + P + L - y(P + L)] \\ F(y) = \frac{dy}{dt} = y(1 - y)[z(R_2 - C_2 - R_3 + C_3) + x(zC + P)] \\ F(z) = \frac{dz}{dt} = z(1 - z)[x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5] \end{cases}$$

The evolutionarily stable strategy (ESS) of the differential equation system can be determined through a local stability analysis of the Jacobian matrix. Let the Jacobian matrix of the system be defined as follows:

$$J = \begin{pmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}$$

Among them, $a_{11} = (1 - 2x)[R_1 - S + P + L - y(P + L)]$, $a_{12} = x(1 - x)(-P - L)$, $a_{13} = 0$, $a_{21} = y(1 - y)(zC + P)$, $a_{22} = (1 - 2y)[z(R_2 - C_2 - R_3 + C_3) + x(zC + P)]$, $a_{23} = y(1 - y)(R_2 - C_2 - R_3 + C_3 + xC)$, $a_{31} = z(1 - z)(C - yC)$, $a_{32} = z(1 - z)(R_4 - R_5 - xC)$, $a_{33} = (1 - 2z)[x(1 - y)C + y(R_4 - R_5) + R_5 - C_4 + C_5]$.

In the replicator dynamic system of local governments, private developers, and villagers, by setting $F(x) = F(y) = F(z) = 0$, we can obtain the local equilibrium points $E_1(0, 0, 0)$.

0, 0), E_2 (0, 0, 1), E_3 (0, 1, 0), E_4 (0, 1, 1), E_5 (1, 0, 0), E_6 (1, 0, 1), E_7 (1, 1, 0), and E_8 (1, 1, 1). According to evolutionary game theory, the necessary condition for the system's evolutionarily stable strategy (ESS) is that all eigenvalues of the Jacobian matrix must have negative real parts. If at least one eigenvalue of the Jacobian matrix has a positive real part, the equilibrium point is unstable. If the Jacobian matrix has eigenvalues with zero real parts and the remaining eigenvalues have negative real parts, the equilibrium point is in a critical state, and stability cannot be determined by the eigenvalues' signs, making it a saddle point. Given the parameter assumptions $R_2 > C_2$, $R_3 > C_3$, $R_4 > C_4$, and $R_5 > C_4$, the values $C_4 - C_5 - R_5$, $C_4 - C_5 - R_4$, $C_4 - C - C_5 - R_5$, and $C_4 - C_5 - R_4$ are all negative, as shown in Table 3.

Table 3. Equilibrium point stability analysis.

Equilibrium Points	Jacobian Matrix Eigenvalues			Real Part Symbol	Results
	λ_1	λ_2	λ_3		
E_1 (0, 0, 0)	$R_1 - S + P + L$	0	$R_5 - C_4 + C_5$	$(\times, 0, +)$	Unstable point
E_2 (0, 0, 1)	$R_1 - S + P + L$	$R_2 - C_2 - R_3 + C_3$	$C_4 - C_5 - R_5$	$(-, -, -)$	ESS
E_3 (0, 1, 0)	$R_1 - S$	0	$R_4 - C_4 + C_5$	$(\times, 0, +)$	Unstable point
E_4 (0, 1, 1)	$R_1 - S$	$C_2 - C_3 - R_2 + R_3$	$C_4 - C_5 - R_4$	$(-, -, -)$	ESS
E_5 (1, 0, 0)	$-R_1 + S - P - L$	P	$C + R_5 - C_4 + C_5$	$(\times, +, +)$	Unstable point
E_6 (1, 0, 1)	$S - P - R_1 - L$	$C - C_2 + C_3 + P + R_2 - R_3$	$C_4 - C - C_5 - R_5$	$(-, -, -)$	ESS
E_7 (1, 1, 0)	$S - R_1$	$-P$	$R_4 - C_4 + C_5$	$(\times, -, +)$	Unstable point
E_8 (1, 1, 1)	$S - R_1$	$C_2 - C - C_3 - P - R_2 + R_3$	$C_4 - C_5 - R_4$	$(-, -, -)$	ESS

2.5. Simulation Analysis of the Tripartite Evolutionarily Stable Strategy

To analyze the signs of the eigenvalues corresponding to different equilibrium points, this study discusses the evolutionary game strategy in four scenarios, which are numerically simulated by Matlab (R2016a) software.

Scenario 1: When $(R_1 + P + L) - S < 0$ and $(R_2 - C_2) - (R_3 - C_3) < 0$, it implies that the local government's cost of supervising developers exceeds the benefits of improved government image, the loss of image from not supervising forced demolitions, and the penalty costs for the private developer's forced demolition strategy. Additionally, the private developer's profits from forced demolition are greater than those from legal demolition. Under these conditions, the eigenvalues of the Jacobian matrix at E_2 (0, 0, 1) all have negative real parts, indicating an evolutionarily stable strategy (ESS) characterized by the strategy of (no supervision, illegal demolition, agreement).

To validate this ESS, simulations were conducted using Matlab. The initial probabilities were randomly set to $x = 0.3$, $y = 0.4$, and $z = 0.2$, and the parameter values were defined as $S = 20$, $U = 2$, $C_1 = 3$, $R_1 = 2$, $L = 5$, $R_2 = 8$, $R_3 = 20$, $C_2 = 7$, $C_3 = 1$, $P = 7$, $C = 8$, $C_0 = 7$, $R_4 = 5$, $R_5 = 5$, $C_4 = 4$, and $C_5 = 3$. The results of this tripartite evolutionary game simulation are shown in Figure 1a. As time t progresses, the proportion of the local government adopting the supervision strategy decreases due to high supervision costs, eventually reaching zero. The proportion of private developers opting for legal demolition decreases over iterations, also approaching zero. Meanwhile, the proportion of villagers accepting redevelopment strategy increases, approaching one. The system ultimately reaches the equilibrium point (0, 0, 1), representing the evolutionary strategy of (no supervision, illegal demolition, agreement). These results indicate that high supervision costs lead the government to prefer a "no supervision" strategy. In response, private developers, aiming to maximize their interests, often resort to coercive measures like cutting off water and electricity, threats, and intimidation to force relocations—an embodiment of the "forced demolition" strategy. Over time, and through continuous interactions, even initially resistant villagers tend to adopt the "contract signing" strategy, weighing the costs and benefits. However, the illegal methods used by private developers during forced demolitions harm villagers' legitimate interests. Consequently, the evolutionary strategy of (no supervision, illegal demolition,

agreement) may provoke conflicts between private developers and villagers, potentially jeopardizing social harmony and stability.

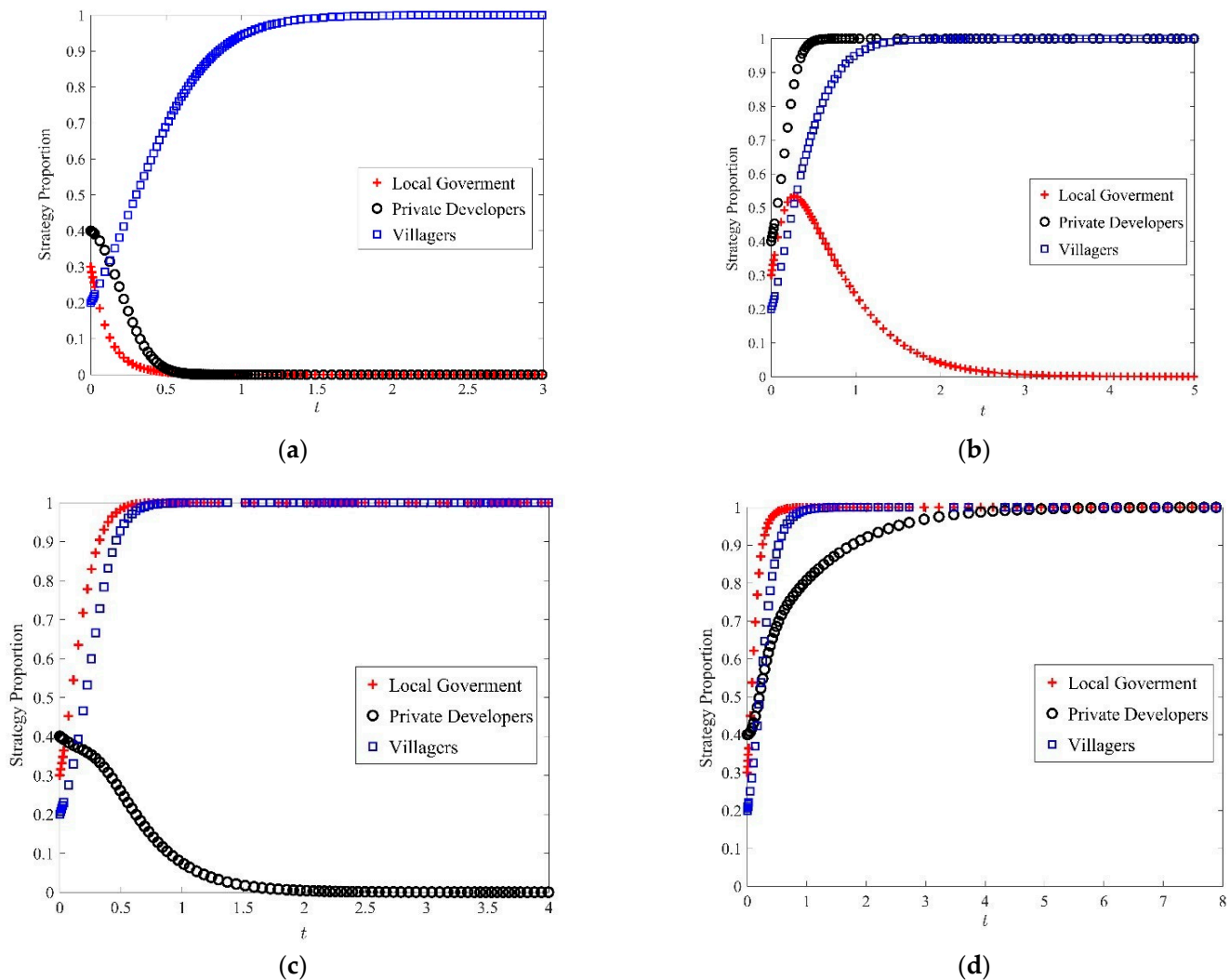


Figure 1. Dynamic evolutionary game diagram of local government, private developers, and villagers. (a) Scenario 1. (b) Scenario 2. (c) Scenario 3. (d) Scenario 4.

Scenario 2: When $R_1 - S < 0$ and $(R_3 - C_3) - (R_2 - C_2) < 0$, it indicates that the local government's cost of supervising private developers exceeds the benefits of improved government image, and the private developer's profit under the forced demolition strategy is less than the profit under the legal demolition strategy. In this case, the eigenvalues of the Jacobian matrix at $E_4 (0, 1, 1)$ have all negative real parts, indicating an evolutionarily stable strategy characterized by the strategy of (no supervision, legal demolition, agreement).

Similarly, to validate the above analysis, the initial probabilities were randomly set to $x = 0.3$, $y = 0.4$, and $z = 0.2$, and the parameter values were defined as $S = 4$, $U = 2$, $C_1 = 3$, $R_1 = 2$, $L = 8$, $R_2 = 18$, $R_3 = 10$, $C_2 = 7$, $C_3 = 10$, $P = 7$, $C = 8$, $C_0 = 7$, $R_4 = 5$, $R_5 = 5$, $C_4 = 4$, and $C_5 = 3$. The results of this tripartite evolutionary game simulation are shown in Figure 1b. Over time, the government's strategy proportion approaches zero, while the proportions for private developers and villagers approach one. This simulation indicates that when supervision costs exceed the benefits of improved government image, the government will ultimately choose the "no supervision" strategy. As long as the net profit under the legal demolition strategy is greater than under the forced demolition strategy, private developers will choose the "legal demolition" strategy. In this scenario, villagers will tend to accept urban village redevelopment. This evolutionary strategy is

unlikely to cause demolition conflicts, as private developers will be inclined to proceed with legal demolitions and villagers will actively cooperate with the demolition process, making this tripartite evolutionary game an ideal decision-making state.

Scenario 3: When $S - (P + R_1 + L) < 0$ and $[C + P + (R_2 - C_2)] - (R_3 - C_3) < 0$, it implies that the local government's cost of supervising the private developer is less than the combined benefits of the improved government image from supervision, the losses in government image from not supervising the private developer's forced demolition, and the punishment cost to the private developer conducting illegal demolition. Additionally, the developer's net gain $(R_3 - C_3)$ from the forced demolition strategy is greater than the sum of the punishment cost from the local government, compensation to the villagers, and the net gain from the legal demolition strategy $(R_2 - C_2)$. Specifically, if these conditions hold true, the eigenvalues of the Jacobian matrix for the state $E_6 (1, 0, 1)$ will all be negative, indicating that this point is an evolutionarily stable strategy characterized by the strategy of (supervision, illegal demolition, agreement).

The initial probabilities are randomly assigned as follows: $x = 0.3$, $y = 0.4$, and $z = 0.2$. The parameter values are specified as $S = 2$, $U = 2$, $C_1 = 3$, $R_1 = 2$, $L = 8$, $R_2 = 8$, $R_3 = 20$, $C_2 = 7$, $C_3 = 1$, $P = 7$, $C = 8$, $C_0 = 7$, $R_4 = 5$, $R_5 = 5$, $C_4 = 4$, and $C_5 = 3$. The simulation results of this tripartite evolutionary game are depicted in Figure 1c. Over time, the values representing the local government and villagers converge to 1, while those for the private developer iteratively approach 0. This indicates that the government increasingly adopts the "supervision" strategy, the villagers tend towards the "agreement" strategy, and the private developer tends towards the "forced demolition" strategy. The simulation results suggest that when the cost of supervision is low, the government prefers the "supervision" strategy. Despite external oversight by the government and the costs associated with penalties from the local government and compensation to villagers, the net benefits of the forced demolition strategy remain substantial. Therefore, private developers continue to opt for the "forced demolition" approach. In this scenario, although villagers eventually adopt the "agreement" strategy, conflicts are likely to emerge between developers and villagers during the transition to a stable state, which could jeopardize social stability.

Scenario 4: When $S - R_1 < 0$ and $(R_3 - C_3) - [C + P + (R_2 - C_2)] < 0$, meaning that the cost of supervision is less than the reputational benefits the local government gains from supervising the private developer, and the developer's net profit under the forced demolition strategy $(R_3 - C_3)$ is less than the sum of the penalties imposed by the local government for forced demolition, compensation to villagers, and the net profit under the legal demolition strategy $(R_2 - C_2)$, the eigenvalues of the Jacobian matrix corresponding to $E_8 (1, 1, 1)$ all have negative real parts. This point is an evolutionarily stable strategy (ESS), with the corresponding evolutionary strategy being (supervision, legal demolition, agreement).

The initial probabilities are randomly assigned as follows: $x = 0.3$, $y = 0.4$, and $z = 0.2$. Parameter values are specified as $S = 2$, $U = 2$, $C_1 = 3$, $R_1 = 4$, $L = 8$, $R_2 = 9$, $R_3 = 20$, $C_2 = 7$, $C_3 = 1$, $P = 10$, $C = 8$, $C_0 = 7$, $R_4 = 5$, $R_5 = 5$, $C_4 = 4$, and $C_5 = 3$. The simulation results of this tripartite evolutionary game, as depicted in Figure 1d, show that over time, the iterative values for the government, private developers, and villagers converge to 1. The simulation results indicate that if supervision costs are low, the government is more likely to adopt a "supervision" strategy. Due to external oversight, if private developers engage in forced demolition, they will incur government penalties and compensation costs to the villagers. Consequently, private developers are likely to adopt a "legal demolition" strategy. Villagers, in turn, will tend to choose the "agreement" strategy. This evolutionary strategy highlights that government oversight of private developers' demolition activities can promote social stability, as legal demolitions conducted by developers with active cooperation from villagers are unlikely to provoke social unrest.

3. Analysis of the Triangular Game in Urban Village Redevelopment

3.1. Case Selection

This paper selects the XC village redevelopment projects in Guangzhou, China as a case study to support the simulation results of the stabilization strategy of the tripartite evolutionary game. There are four reasons for this: First, XC village is redeveloped using the institutional arrangement of bottom-up with private developer funding, which aligns with the urban village redevelopment model explored in the above game model and involves the interests of the local government, the private developers, and the villagers. Second, it is consistent with the villagers' strategy of "agreement" or "resistance" in the evolutionary game model of this paper. XC village, as one of the representative villages of urban village redevelopment in Guangzhou, started its redevelopment plan along with the official launching of the urban village redevelopment of Guangzhou. The redevelopment was originally planned to be completed in three and a half years, but more than ten years have passed since the start of the redevelopment, and XC village has not yet achieved a 100% signing rate and demolition rate. Third, the XC village redevelopment project is consistent with the "legal demolition" or "illegal demolition" strategy adopted by private developers in the evolutionary game model of this paper. During the redevelopment process, violent conflict events occurred among the interested parties, including villagers' marches, demonstrations, and even "bloodshed" events. In addition, private developers are suspected of forced demolition in the process of urban village redevelopment. Fourth, it is consistent with the assumptions about the strategy adopted by the government in the game model. In earlier years, XC village had stalled the redevelopment projects for many years due to the rent-seeking behavior of the village cadres, which harmed the interests of the villagers. In 2015, the provincial disciplinary committee intervened to investigate the corruption, and after the corrupt officials were disposed of, the redevelopment of XC village was restarted with the impetus of other developers. The redevelopment course of XC village reflects the change in the local government's attitude towards illegal demolition and relocation behaviors.

3.2. Case Description

XC village is located in Tianhe District, Guangzhou, China, covering an area of 3.6 square kilometers with around 5000 villagers. In 2009, XC village was included in Guangzhou's first batch of urban village redevelopment projects. Due to the corruption of village cadres, most villagers resisted the redevelopment projects and called for the village committees to disclose village finances and collective assets by demonstrations. In May 2010, the village committees signed a demolition compensation agreement, requiring the village to hand over land within a specified timeframe. However, the village committee still refused to disclose the compensation amounts. At the same time, the local government aims to expedite the redevelopment to improve the city image because of holding the upcoming Asian Games. Then, conflicts intensified between stakeholders. On the evening of August 12, urban management and security personnel gathered at the XC village Primary School, while villagers assembled at the market opposite. At midnight on August 13, security forces advanced towards the market but were repelled by villagers throwing stones. At 3 a.m., security forces launched another assault using tear gas and high-pressure water cannons, dispersing the crowd. Sixteen large excavators then demolished the surrounding walls. Following the clearance, the market was razed. During the conflicts, villagers reported approximately 50 injuries, with over a dozen hospitalized and two seriously injured. Official accounts noted two injured demolition workers and three damaged excavators.

In 2011, the comprehensive demolition phase began, led by BL private developers. By 2014, most villagers had signed contracts, and BL private developers provided temporary relocation fees and subsidies. The full-scale construction of the XC village redevelopment project was set to begin in 2015, starting with the reconstruction of the first phase of resettlement housing. In 2018, the first batch of residents moved into the resettlement housing. According to the "Detailed Control Plan for the XC village Plot", the total

construction area within the redevelopment scope is 1.077 million square meters, with a floor area ratio of 6.99, consistent with the original plan. The residential area in the resettlement zone is 425,000 square meters, public service facilities occupy 25,000 square meters, and commercial and apartment areas cover 170,000 square meters. The financing zone comprises 457,000 square meters, designated for commercial or business purposes. To ensure the smooth progress of the redevelopment and to maximize the benefits for the villagers, more areas were allocated for residential, public service, and municipal facilities compared to the original plan. As of July 2021, the signing rate of XC village had reached 99.08%, and the demolition rate was 98.13%. However, a small number of XC villagers still refuse to sign contracts, becoming so-called “nail households”. On 5 December 2023, XC village conducted a vote regarding the reclaiming of collective land use rights of “nail households” within the designated area of the redevelopment project. With a remarkable approval rate of 94%, this vote represents a significant milestone in addressing the relocation of the remaining households within the village.

3.3. Case Analysis of Simulation Results for Tripartite Evolutionary Game

3.3.1. The Scenario of “Illegal Demolition” Strategy Adopted by Private Developers

The two equilibrium strategies E_2 (no supervision, illegal demolition, agreement) in Scenario 1 and E_6 (supervision, illegal demolition, agreement) in Scenario 3 show that regardless of the strategy adopted by the government, when private developer adopts the strategy of “illegal demolition” and the villagers adopt the strategy of “agreement”, there is a higher probability that it will lead to the occurrence of social instability. The private developers will adopt a forced demolition strategy when their profits from forced demolition are greater than those from legal demolition, or when their net gain ($R_3 - C_3$) from the forced demolition strategy is greater than the sum of the punishment cost from the local government, compensation to the villagers, and the net gain from the legal demolition strategy ($R_2 - C_2$). This is because the schedule delay will cause more monetary loss to the developers, who will risk breaking the law to force the villagers to sign the contract and carry out forced eviction. At this point, the villagers will resort to confrontation and resistance in order to protect their own interests. Under such circumstances, the factors of insecurity and instability in the redevelopment of urban villages become more prominent.

The findings of this simulation are consistent with those of the XC village redevelopment project. The strategic choices of private developers are influenced by the profits from redevelopment, while the choices of villagers are shaped by the amount of compensation they gain. Private developers aim to maximize the building area, particularly for commercial construction land, and seek to assemble land quickly for construction. In order to avoid incurring additional costs for a land development project that takes too long, the BL private developer wants the villagers to sign the contract as soon as possible. Those villagers in XC village who do not agree to be relocated under contract will affect the progress of the whole project, which in turn will increase the developer’s cost to a certain extent. As a staff member from a BL private developer said:

“The villagers expect that the compensation for areas of balconies and bay windows should be the same as the building plot. Given our substantial construction demands, this approach would result in a shortfall of construction space. ... Households that refuse to relocate cause construction delays and significant financial losses. The temporary costs exceed 10 million yuan per month, excluding financial and labor costs. If we cannot demolish smoothly, we face numerous breach of contract issues, but we cannot be entirely blamed for the demolition problems”.

Since the commencement of the demolition and remodeling of XC village in December 2009, there are still a few villagers who are unwilling to sign. For more than a decade, the “nail households” have been deadlocked, resulting in the slow redevelopment of some plots. “Nail householders” are concerned that the relocated high-rise buildings, with collective property rights, cannot be traded on the market. Additionally, the unequal area

of resettlement housing discourages relocation, hindering the progress of urban village redevelopment projects. As a “nail householder” mentioned:

“If we sign the agreement, this building only provides two resettlement apartments without certificates, which are collective property rights housing. We are just allowed to live there. For example, if the house is 100 square meters, they return 80 square meters to you, and the remaining 20 square meters are shared”.

Another “nail householder” from XC village mentioned the following:

“While the developer was working, their excavator was tearing down the house next to mine, deliberately messing up the walls of my house. I’ve also heard that because of the construction, the utilities of several houses that have not yet been relocated have been affected. Aren’t they trying to force us out of here by such improper means?”

In the case of XC village, the villagers were dissatisfied with the compensation plan and the quality of the resettlement and relocation houses and chose the “resistance” strategy, which prevented the developer from proceeding with the construction as planned and resulted in increased costs. Faced with huge costs, the developer had to resort to “illegal demolition”. It was reported that during the demolition of the XC village market in 2010, more than 200 people gathered at the demolition site to obstruct the demolition, confronting the urban management and demolition personnel at the site, and a few villagers violently attacked law enforcement personnel, resulting in injuries to some of them. The social mass incident in XC village shows that the developer’s strategy of “illegal demolition” ignores the villagers’ demands, and the conflicts and contradictions between them will become more and more acute. Although the simulation results in this paper show that the villagers’ choice of the “contracting” strategy tends to stabilize, this process is often accompanied by incidents of resistance to demolition, obstruction of construction, and appeals to higher levels.

3.3.2. The Scenario of the “Legal Demolition” Strategy Adopted by Private Developers

The two equilibrium strategies E_4 (no supervision, legal demolition, agreement) in Scenario 2 and E_8 (supervision, illegal demolition, agreement) in Scenario 4 show that regardless of the strategy adopted by the government, it is unlikely that social unrest will be triggered when private developer adopts the strategy of “legal demolition” and the villagers adopt the strategy of “agreement”. This is because the developer’s legal demolition and relocation procedures minimize the villagers’ dissatisfaction. At the same time, under the effective supervision of the local government, the investigation and punishment of corruption and violent demolition and relocation can better protect the interests of the villagers, which allows the whole urban village redevelopment project to be carried out more smoothly.

The case of XC village similarly corroborates this simulation conclusion. The interaction between the local government and the villagers centers on the government’s need to monitor the misconduct of private developers and village cadres. The government aims to expedite the urban village redevelopment process, improving city image and optimizing land use efficiency. However, historical corruption within the village collective during earlier redevelopment phases necessitates stringent supervision by the local government to safeguard villagers’ interests, maintain social stability, and prevent mass incidents. In the context of strictly regulating the management of land acquisition and relocation and resolutely correcting illegal land acquisition and relocation, the Guangdong Provincial Commission for Discipline Inspection (GDCDI) intervened to investigate the corruption in XC village, and after the corrupt officials were disposed of, the redevelopment of XC village was re-launched. In 2018, the meeting of the Guangzhou Urban Renewal Leadership Group considered and passed the redevelopment and adjustment plan for XC village. As a staff member from XC Street said:

“The district government has always prioritized the redevelopment of XC village. In 2019, a second redevelopment notice was issued because this project genuinely benefits the villagers. We hope that the remaining villagers will sign the contracts and return soon. However, historical issues have caused some villagers to be reluctant to sign”.

Given the historical issues in XC village, the local government prioritizes correcting illegal land acquisition and demolition practices and supervises developers’ activities to smooth urban village redevelopment. The government staff from XC Street continued:

“Due to the prolonged delay in the XC village redevelopment project, the village company exhausted all funds borrowed from banks and the finance bureau, ultimately leading to bankruptcy. Subsequently, XC village cooperates with the BL private developer to initiate the redevelopment project, securing redevelopment funds through land transfer. . .during the redevelopment process, private developers made errors in demolition, causing significant dissatisfaction among villagers. Therefore, we have sent official personnel to supervise the site work together with the villagers, which has yielded better results”.

Under the effective supervision of the local government and its active promotion, the phenomenon of illegal forced land acquisition and demolition has been reduced. As of 2021, the signing rate of XC village reached 99% and the house demolition rate reached 98%. The case of XC village demonstrates that effective government supervision and legal demolition by developers can better avoid the occurrence of vicious incidents caused by land acquisition and relocation.

4. Governance Strategies for High-Quality Urban Village Redevelopment

The simulation results of the game model and the case of XC village together illustrate the conclusion that in the scenario where the private developer adopts the strategy of forced demolition and relocation, even though the villagers ultimately choose to enter into a property exchange contract, social conflicts are easily triggered in the process of urban village renewal. By reducing the cost of government supervision, increasing the cost of forced demolition by private developers, and safeguarding the legitimate rights and interests of villagers in these three areas, it is conducive to the formation of a tripartite redevelopment alliance to promote the smooth implementation of urban village renewal projects. According to the above findings, we can put forward some management inspirations and suggestions.

Firstly, a social and public monitoring mechanism should be established to reduce the cost of government supervision. Local governments should encourage “third-party force” social organizations and “fourth-party power” public media to play a good monitoring role. This system aims to promptly identify any misconduct by developers or village collectives and to prevent conflicts of interest arising from the misuse of public power by local officials. Additionally, local governments should take advantage of the use of news media, online platforms, and other modern information dissemination tools to strengthen the supervision of private developers’ demolition and relocation behavior. The participation of social forces can not only effectively reduce the abuse of power by administrators, but can also, to a large extent, curb the emergence of corruption and effectively reduce the cost of local government administration and the burden of supervision.

Secondly, the government should regulate housing expropriation, demolition, and relocation, and investigate and deal with developers’ illegal acts of forced expropriation and demolition. This regulatory measure can, to a certain extent, increase the cost of forced demolition for private developers, thus ensuring that developers carry out urban village redevelopment under legal procedures. From the perspective of stakeholder theory, the core of urban village redevelopment lies in interests redistribution of various stakeholders. Scholars have noted that, compared to Western countries, local governments in China play a more prominent role [50]. State intervention acts as an effective coordinator to rebalance power relations between the state, market, and society in the urban village redevelopment process [8]. Private developers are crucial in project financing, but their powers must be

constrained by local governments. Penalizing developers for violations can avoid forced evictions and illegal activities.

Thirdly, establishing channels for villagers to express their demands and safeguarding their legitimate rights and interests is an important condition for ensuring villagers' contracting. Local governments need to set rules for interest representation and conflict resolution to reduce transaction costs due to information asymmetry [51]. Specific measures may include strengthening and improving the petition system, unblocking and standardizing channels for public demand expression, and rights protection. The government encourages village collectives to hold regular village representative meetings to convey redevelopment information and collect villagers' demands. Negotiation is an effective means of interest representation and a primary method for conflict resolution, characterized by low costs. However, unequal negotiation capacities can lead to uneven benefit distribution, which is a major cause of conflicts. Thus, in order to mitigate conflicts arising from relocation and compensation demands, the government must regulate the negotiation rules and balance the bargaining powers of stakeholders to ensure social fairness and justice [30]. Additionally, guiding villagers to develop and utilize their economic reserved land can enhance the collective income of the village, ensuring sustainable post-redevelopment income and increasing the opportunity cost for villagers resisting urban village redevelopment.

5. Conclusions

This paper focuses on urban village redevelopment projects implemented under bottom-up institutional arrangements based on evolutionary game theory. Under the assumption of limited rationality, a tripartite game model involving local governments, private developers, and villagers was constructed for the urban village redevelopment process. The paper derived the tripartite evolutionarily stable strategies and their gaming trends under four scenarios and used simulation methods to verify the stable strategies. In scenarios where private developers adopt forced demolition strategies, although villagers ultimately choose to sign the contract of property exchange, it can easily lead to social conflicts during the process. This conclusion echoes the case study of the XC village redevelopment projects. Reducing the government's supervision costs and increasing the private developers' forced demolition costs can easily form a tripartite redevelopment alliance. Based on this research, the following governance strategies are proposed to smoothly and steadily promote urban village redevelopment: constructing a diverse and collaborative supervision mechanism, streamlining channels for villagers' expression of demands, and enhancing the mechanism for coordinating interests throughout the entire redevelopment process.

However, due to insufficient objective conditions and limitations in subjective capabilities, this paper has certain limitations. First, there is a need to improve the selection of variables. This paper mainly considers the benefits of local governments, private developers, and villagers from a "benefit-cost" perspective. However, in reality, the decision-making process takes into account not only benefits and costs but also personal emotions, which are not considered in this paper. Future studies can consider more influencing factors when analyzing the tripartite evolutionary game. Second, although some studies reveal that the village covers all villagers, the number of survey samples is insufficient. Due to time and resource constraints, this paper only conducted relevant research in Village F, Guangzhou, and understood the interests of local governments, developers, and villagers in the process of urban village redevelopment. If the sample size and data of the survey are increased, the analysis and demonstration of the tripartite game relationship could be more accurate.

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