The Evolutionary Game Study of Social Integration of Floating Population in Wuhan

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Abstract. Examining the influencing factors of social integration among the floating population in Wuhan is of significant importance for fostering the healthy development of the social economy and constructing a more inclusive and equitable social environment. By constructing a two-party game model between the Wuhan municipal government and the floating population, this study deduces and verifies the evolutionary process and influencing factors of stable strategies for each participant. The research indicates that economic integration, policy acceptance, and socio-cultural factors contribute to promoting the evolution of the floating population in Wuhan towards active integration.

Keywords: Migrant Populations, Social Integration, SEM, Wuhan

1 Introduction

The social integration of the floating population significantly impacts urbanization quality. Population mobility drives economic development but also poses integration challenges. Fair treatment and social welfare access directly influence their social integration, reflecting a city's people-oriented service concept[1]. Challenges persist in Wuhan, where household registration restrictions impede employment, education, and healthcare access[2]. High housing costs push many to outskirts or basic accommodations, affecting their quality of life. Cultural differences further hinder local society integration, leading to a low sense of belonging and marginalization. This article aims to improve public services and social management for Wuhan's floating population, enhancing their social integration and promoting the region's socioeconomic development. It constructs a two-party game model between the Wuhan municipal government and the floating population, exploring factors influencing social integration and analyzing strategic choices. The evolutionary game model is preferred for its dynamic nature, offering a direct demonstration of the floating population's behavioral strategies.

2. Description of the Evolutionary Game Model

2.1 Model Agents and Behavioral Strategies

In this economic system, we focus on the Wuhan municipal government and a subset of the floating population. Each game pairs a member of the floating population with the government, forming an evolutionary model. The government's strategies are 'active' and 'passive', while the

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population's are 'active integration' and 'passive integration'. Due to policy, behavior, and information complexities, both parties struggle to choose optimally[3]. As boundedly rational actors in long-term cooperation, they select strategies based on their interests. In a dynamic environment, both continuously adjust until reaching stability[4].

2.2 Model Assumptions and Parameter Settings

Assumption 1: The Wuhan Municipal Government's "active" strategy improves the floating population's quality of life, reduces social instability, and enhances harmony, yielding a benefit of W_1; the "passive" strategy's benefit is W_2, with $W_1 > W_2$.

Assumption 2: Greater economic integration with the Wuhan Municipal Government's "active" strategy than the "passive" one benefits the floating population, reducing relative deprivation. Economic integration levels for "active" and "passive" strategies are F_1、$F_2(0 < F_2 < F_1)$.

Assumption 3: The floating population's "active integration" strategy improves local integration, gaining recognition and support, with benefit S. Economic integration affects the total benefit $G_i = F_i \cdot S$.

Assumption 4: Improved policies benefit the floating population, enhancing public services and interaction with locals. Policy acceptance indicators for "active" and "passive" strategies are H_1、$H_2(0 < H_i < 1，H_1 < H_2，i = 1、2)$, with $H_i = T_i \cdot F_i \cdot Q_i，(i = 1、2)$, where T_i is policy improvement, F_i is inclusiveness, and Q_i is evaluation.

Assumption 5: Costs for the Wuhan Municipal Government's "active" (C_1) and "passive" (C_2) strategies are $C_1 > C_2$.

Assumption 6: Reputation benefits for the Wuhan Municipal Government from the floating population's "active integration" strategy are $A_1 > A_2$.

Assumption 7: Integrating into local social culture enhances the floating population's sense of belonging. Social and cultural benefits for "active" (U_1) and "passive" (U_2) strategies are $U_1 > U_2$.

Assumption 8: Time costs for the floating population are $K_1 > K_2$ when choosing "active" or "passive" integration strategies.

2.3 Construction of Evolutionary Game Theory Model

This section analyzes the benefits of the Wuhan Municipal Government and the floating population in the evolutionary system, based on the model assumptions, and presents the evolutionary game payoff matrix in Table 1.

Table 1. Results of Reliability Test

		The Wuhan Municipal Government	
		active	passive
floating population	active integration	$H_1F_1S - K_1 + U_1$ $W_1 - C_1 + A_1$	$H_2F_2S - K_1$ $W_2 - C_2 + A_2$
	passive integration	$-K_2 + U_2$ $W_1 - C_1$	$-K_2$ $W_2 - C_2$

For the floating population, the expected benefits of choosing strategies are:

$$U_{x1} = y(H_1F_1S - K_1 + U_1) + (1-y)(H_2F_2S - K_1)$$

$$U_{x2} = y(-K_2 + U_2) + (1-y)(-K_2)$$

For the Wuhan Municipal Government, the expected benefits are:

$$U_{y1} = x(W_1 - C_1 + A_1) + (1-x)(W_1 - C_1)$$

$$U_{y2} = x(W_2 - C_2 + A_2) + (1-x)(W_2 - C_2)$$

Therefore, the replicator dynamic equation for the floating population adopting the "active integration" strategy is:

$$X = \frac{dx}{dt} = x(1-x)(U_{x1} - U_{x2})$$

$$= x(1-x)[y(H_1F_1S - H_2F_2S + U_1 - U_2) + K_2 - K_1 + H_2F_2S]$$

Similarly, we can derive the replicator dynamic equation for the Wuhan Municipal Government adopting the "active" strategy as:

$$Y = \frac{dy}{dt} = y(1-y)(U_{y1} - U_{y2})$$

$$= y(1-y)[x(A_1 - A_2) + C_1 - C_2 + W_1 - W_2]$$

Using Friedman's criterion, we analyze the local stability of the system's Jacobian matrix. By taking partial derivatives of the functions with respect to x and y, we obtain the Jacobian matrix J:

$$J = \begin{bmatrix} \frac{\partial X}{\partial x} \frac{\partial X}{\partial y} \\ \frac{\partial Y}{\partial x} \frac{\partial Y}{\partial y} \end{bmatrix} = \begin{bmatrix} a_{11} a_{12} \\ a_{21} a_{22} \end{bmatrix}$$

$$a_{11} = (1-2x)[y(H_1F_1S - H_2F_2S + U_1 - U_2) + K_2 - K_1 + H_2F_2S]$$
$$a_{12} = x(1-x)(H_1F_1S - H_2F_2S + U_1 - U_2)$$
$$a_{21} = y(1-y)(A_1 - A_2)$$
$$a_{22} = (1-2y)[x(A_1 - A_2) + C_2 - C_1 + W_1 - W_2]$$

To achieve evolutionary stable strategies in the model, it is necessary to satisfy the condition $(1) tr(J) = a_{11} + a_{22} < 0$, $(2)\ det(J) = a_{11}a_{22} - a_{12}a_{21} > 0$.

2.4 Construction of Evolutionary Game Theory Model

The stability of the five equilibrium points can be analyzed using the Jacobian matrix stability analysis method, as shown in Table 2.

Table 2. Local Stability Analysis of Evolutionary Game Model

Equilibrium Points	Determinant Symbol	Trace Symbol	Local Stability
$F(0, 0)$	+	-	ESS

$E(0，1)$	+	+	Unstable
$C(1，0)$	+	+	Saddle Point
$D(1，1)$	+	-	ESS
$O(p^*，q^*)$	-	+	Saddle Point

Table 2 shows that only points F (0,0) and D (1,1) meet the criteria for evolutionarily stable strategies among the five equilibrium points. Points E (0,1) and C (1,0) are unstable, and point O (p*,q*) is the critical saddle point of the game.

3. Matlab numerical simulation

Based on the analysis, the Wuhan municipal government and the floating population may adopt strategies of (positive, active integration) and (negative, passive integration). The system's final convergence depends on parameter changes. To guide strategies optimally, the team used MATLAB for numerical simulations, estimating parameters with relative, dimensionless values[5]. Specific values are in Table 3.

Table 3. Initial parameter values

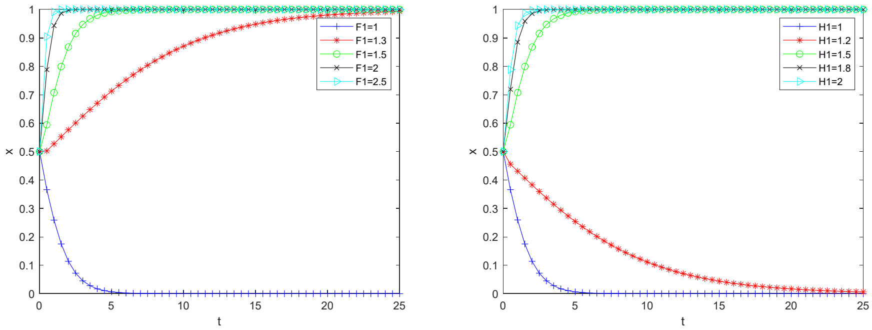
parameter	W_1	F_1	H_1	B_1	U_1	C_1	A_1	K_1	x	S
assignment	20	2	2	5	20	30	3	8.5	0.5	2
parameter	W_2	F_2	H_2	B_2	U_2	C_2	A_2	K_2	y	
assignment	10	1	1	10	19.5	20	2	3	0.5	

3.1 Economic integration

Economic integration offers better education and development opportunities to the floating population, aiding in their adaptation to new environments. Figure 1(a) demonstrates its positive impact on their social integration. As economic integration F_1 rises, so does the likelihood of the floating population choosing "active integration." At F_1=1, they tend to choose "active integration," and as F_1 increases （$F_1 = 1.3$、1.5、2、2.5）, the probability of this choice converges to 1.

3.2 Policy acceptance

Policy acceptance, through diverse support and guarantees, drives the social integration of the floating population. Figure 1(b) illustrates its impact: as city mobility levels (H_1) gradually rise, so does the probability of the floating population opting for "active integration." When H_1 reaches 1 or 1.2, they tend towards "passive integration," but with further increases ($H_1 =$ 1.5、1.8、2), their choice converges to "active integration." This shows that policy acceptance fosters the social integration of the floating population.



(a) (b)

Figure 1. Simulation results of economic integration and policy acceptance changes

3.3 Social culture

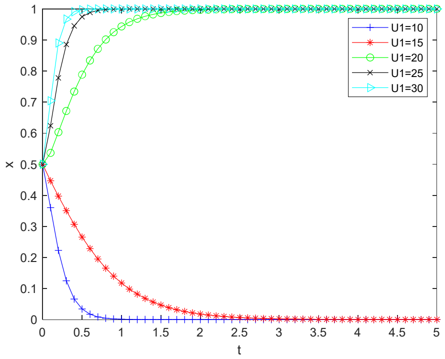


Figure 2. Simulation Results of Policy Acceptance Changes

Social and cultural factors are crucial in promoting the social integration of the floating population. By enhancing their sense of belonging and participation through interaction with the local community, these factors drive integration in education, employment, and social activities. Figure 2 illustrates how the social and cultural level impacts the floating population's social integration. As the social and cultural level U_1 increases, the probability of the floating population choosing the "active integration" strategy also rises. For U_1 values of 10 and 15, the floating population tends to choose "active integration," with probabilities converging to 1 as U_1 increases to 20, 25, and 30. These simulation results highlight how social and cultural levels can stimulate the floating population's social integration.

4.Conclusions

This study explores how economic integration, policy acceptance, and socio-cultural factors influence the social integration of migrant populations in Wuhan. It constructs a two-player evolutionary game model between migrants and the Wuhan government, incorporating these factors. Through MATLAB simulation, the study shows their positive impact on social integration.

In addition, this study has some limitations. In the numerical simulation analysis, the parameter replication in this paper is somewhat subjective and lacks support from real data. Future research could further validate the game model through questionnaire surveys or collecting relevant secondary data.

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