Where Do They Move from Here?
"Voting with the Feet" Principle through Agent Simulation

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Abstract This paper describes an agent-based simulation model to analyze voting behaviors of individual in several political regions. In the model, plural political decisions in each region are made by the corresponding regional government, and the inhabitants will vote the decisions based on their preferences. Both governments and individuals are modeled as decision making agents. The intensive simulation studies have revealed the emergence of decision groups and how the decision have been made.

Keywords: Agent-Based Modeling, Voting with the feet, Social Systems

1. INTRODUCTION

Although the recent globarization of the world countries, the roles of local governments have become much more important for the inhabitants, because of the urgent needs for effective resource allocation of the region. It is known that the analysis on people's movement in living regions is one of such activities, although each regidents believe that the activities are based on with their own decisions.

Tiebot [1] proposed the concept of "Voting with Feet" (VWF) to give a theoretical foundation of changes of local governance. VWF means such mechanisms that 1) When there are a lot of local governments in a coutry, 2) Each local government proposes its own tax system and politicla service systems as its policies, 3) Based on the proposals, each inhabitant selects his/her best local government and move to the place, 4) Local governments compete with each other to improve the policies, and 5) As a result, local governents will have the incentives for effective political services.

The mechanisms assume that 1) Every inhabitant has complete knowledge about the cost (tax) and benefits (utilities) of the political systems proposed by local governments, 2) Every inhabitant makes the decision where to live based on the knowledge and 3) the cost of migration of inhabitants is enough small for them. Of courese, the assumptions would not hold in the real countries. However, if we would accept the assumtions, the changes or improvements of the policies of local governments might cause homogeneous political system over the whole country, because they imitate better polocies each other, and might result in the limited migration of inhabitants.

Based on the above background, this paper investigates the properties of VWF through agent-based modeling techniques: 1) we have implemented a simulation system, and 2) Using the simulator, we have studied how the difference of policies of each loca govenments affect the migration of the inhabitants. The rest of the paper is organized as follows: Section 2 surveys related work in the literature; Section 3 explains the outline of the agent-based simulation model; Section 4 gives the results of intensive simulation experiments and discussions about them; and Section 5 is the concluding remarks.

2. RELATED WORK

2.1 Agent-Based Modeling Agent-based modeling (ABM) employs the concepts of agents: software with the functionalities of internal states, decision rules for problem solving, and communication mechanisms [2]. We would like to observe macro-level phenomena caused by the bottom-up effects among agent interactions and evaluate the phenomena as a model of social system design.

Axelrod [3] has stated the importance of the ABM as follows: Although agent-based modeling employs simulation, it does not aim to provide an accurate representation of a particular empirical application. Instead, the goal of agent-based modeling is to enrich our understanding of fundamental processes that may appear in a variety of applications. This requires adhering to the KISS principle, which stands for the army slogan "keep it simple, stupid". Our simulation model is implemented based on the concept of the KISS principle, however, gives rich interesting resuls as described below.

2.2 Studies about VWF There are a lot of researches in the literature referring to the Tiebout work [1]. Among them, Sharp [4] has estimated that the 2.4% of the population in Kansas in the United States makes migration decisions from the concept of VWF. In Lowery et al. [6] and Percy et al. [7] have conducted survey studies to uncover the migration mechanisms. They have reported that there are contradictive results between the VWF model and survey data. Although the VWF model states the migrations of inhabitants are caused by the comlains about taxes they must pay and the levels of services the local governments give, their investigations have not succeeded in explaining the mechanisms.

In this paper, we will focus on the mechanisms described by the original VWF: both the policy making of local government and decisions by the inhabitants affected by the local policies. We porposed aget-based simulation model with utilities of migration of the inhabitants and policies of local governments. We will investigate the competitive conditions on prulal local governments to acquire more inhabitants in the region.

3. MODEL DESCRIPTION

Our agent-based model consists of a regional system with government agents $LG=\{lg_i \mid i=1,\cdots,m\}$ and inhabitant agents $C=\{c_k \mid k=1,\cdots,n\}$. Government agents provide common services with inhabitants agents. This decisions are made based on the buggets propotional with the inhabitants they have. The govenments agents also open their policies to the inhabitants. In order to have more inhabitants, the govenments make political decisions how to distribute the budgets. On the other hand, the inhabitants agents have their own preferences about the political decisions. Based on the preference, they decide where to move.

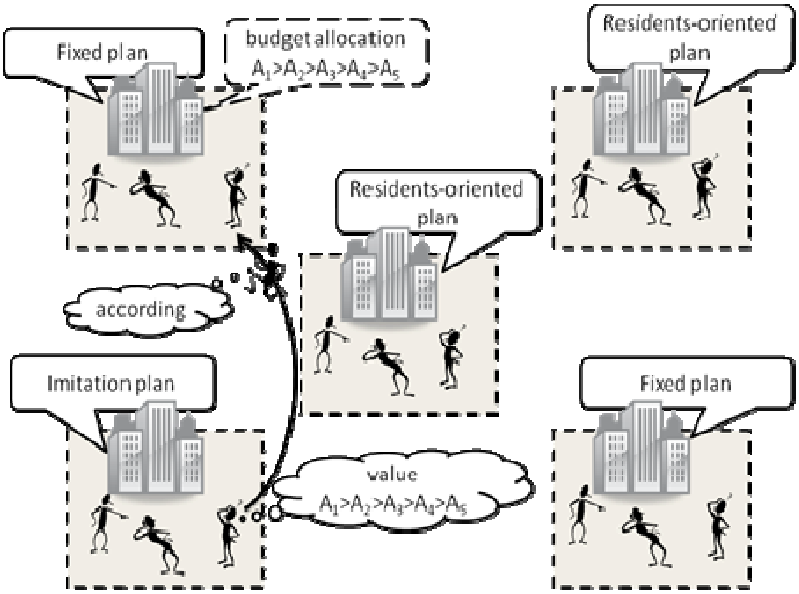

Figure 1. Outline of the Agent-Based VWF Model

3.1 Government Agent Model

3.1.1 Model Basics Each government agent is represented as a tuple $lg_i=\{A_i, T_i, B_i\}$. At each simulation step, a government agent lg_i shows its own local common service set $A_{ij}(t)=\{A_{ij} \mid j=1,\cdots,5\}$ and the local tax $T_i(t)$ to an inhabitant agent c_k. $A_{ij}(t)$ provided by the lg_i is a very abstract concept, but it is corresponding to such social capital services as medical, educational, childcare, transportation, residence, security services as police and fire stations. We further assume that the tax $T_i(t)$ is constant during the simulation.

Each government agent lg_i gathers T_i from a inhabitant agent c_k. The government gets the profit $B_i(t)$ and its changing rate $BS_i(t)$ determined by the following equations:

$$B_i(t)=T_i(t)\times n(C_i(t)), \text{ and}$$

$$BS_i(t)=B_i(t)-B_i(t-1).$$

i)When the service level increases $(BS_i(t)>0)$,

$$A_{ij}(t+1)=A_{ij}(t)+\alpha_i\cdot RA_{ij}\cdot BS_i(t); \quad \text{and}$$

ii)when the service rate decreases $(BS_i(t)\leq 0)$,

$$A_{ij}(t+1)=A_{ij}(t)+RA_{ij}\cdot BS_i(t);$$

where, α_i is a constant parameter to represent the efficiency ofservice. In our simulation, we set α_i is equal to 0.7.

3.1.2 Budget Distribution Strategies A government agent lg_i makes political decisions about the budget distribution in order to have more inhabitants.

We set the following three strategies:

(1) Constant Service Strategy (CSS): Set the ratio for each service constant.

(2)Inhabitant Oriented Service Strategy (HSS): Based on the average of the weights ω_j determined by the following equation, which represent the preference of inhabitants about each service, set the ratio for the services.

(3) Imitating Service Strategy (ISS): In each several simulation steps, set the best strategy of the government, which shows thebest increase of the number of inhabitants during the steps in the whole area.

3.2 Inhabitant Agent Model An inhabitant agent is represented as $c_k = \{V_k, P_k\}$,where V_k represents the attractiveness of the region the agent c_k has and P_k is probability of migration of c_k to the other regions.The attractiveness V_k is determined as follows:

$$V_k = \sum_{j=1}^{n} \omega_j A_j \quad - \omega_s T_j,$$

where, the preference weight ω_j is the importance of the inhabitant to each service, and $\sum_{j=1}^{n} \omega_j = 1$.

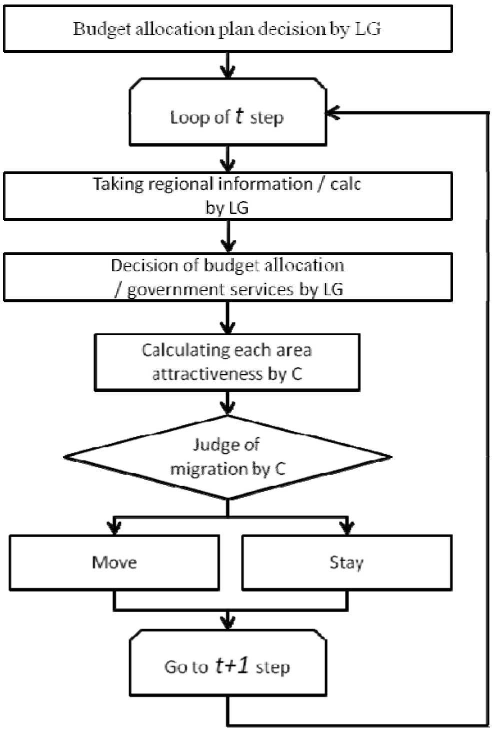

Figure 2. Flow of the Simulation Model

In each simulation step, an inhabitant agent c_k calculates the attractiveness from A_j, and T_j the local government lg_i shows, then compare the best attractive value V_{max} in the regions and the current attractive value V_{new}. The inhabitant agent c_k moves from the current region to the other one with the probability P_k determined by the following equation:

$$P_k = \frac{1}{1 + (\frac{1}{P_0} - 1)e^{-r(V_{max} - V_{new})}}$$

Changing the constant values of r and P_0, the simulator enable us to investigate the utility and easiness of the migration of inhabitants. The proposed model does not include the information of the other properties such as age, sex, psychological, and economical conditions. These properties will be included into our model.

3.3 How the Agent-Based Simulator Works We set initial values of inhabitant agent c_k with uniform random values ω_j, r, and P_0 , where 0.000

$< r, P_0 < 0.001$, and set the inhabitants agents randomly in the regions. The simulation step is depicted in Figure 2 and summarized as follows:

i) A local government lg_i が gets the information the amount of budgets the inhabitant agents want, the number of inhabitants, and the number of the increase/decrease of the population;

ii) The government agent lg_i provides the inhabitant agents with $T_i(t)$ and $A_{ij}(t)$;

iii) An inhabitant agent c_k makes the decision of migration with the probability P_i based on the values of V_k and the information which the government agent lg_i provides to c_k; and

iv) Based on the value of $B_i(t)$, the government agent lg_i determines $A_j(t+1)$ and $T_i(t+1)$.

4. EXPERIMENT AND DISCUSSION

Using the simulation model, we have conducted the following experiments. We set 5 local government agents and 5,000 inhabitant agents. At the first step, the same numbers of inhabitant agents (1,000 eagents) are located in each region. We assume that one step of the simulation is corresponding to one year, and we will observe the changes of 30 years in each simulation. In order to evaluate the effects of different political strategies of the government agents, we set the 6 scenarios shown in Table 1.

4.1 Experimental Results In this subsectin, we will show summarized statistical results of simulation runs and typical simulation results.

4.1.1 STatistics of the Runs For each scenario in Table 1, we have carried out 30 simulation runs. Figure 3 and Table 2 respectgively summarize the average numbers of migrations of inhabitants and their standard deviations after 30 year simulation steps.

From Experimental results, Case 1, where all the local governments keep Fixed Service Strategy with uniformly random budget distributions at the initial step, has shown the highest number of migrations. This means that distributions of the budget causes the encouragement of individual decisions of migrations of the inhabitant agents. Figure 4 shows the changes of inhabitants. The inhabitant agents move frequently.

Table 3. Six Simulation Scenarios

Scenario	lg_1(A)	lg_2(B)	lg_3(C)	lg_4(D)	lg_5(E)
Case1	Fixed	Fixed	Fixed	Fixed	Fixed
Case2	Residents-oriented	Residents-oriented	Residents-oriented	Residents-oriented	Residents-oriented
Case3	Imitation	Imitation	Imitation	Imitation	Imitation
Case4	Imitation	Residents-oriented	Residents-oriented	Fixed	Fixed
Case5	Imitation	Imitation	Residents-oriented	Residents-oriented	Fixed
Case6	Imitation	Imitation	Resident s-oriente	Fixed	Fixed

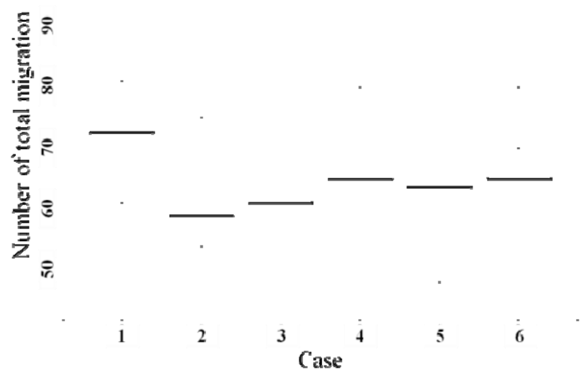

Figure 3. Number of Local Migrations in Each Cases

Table 2. Numbers of Migrations and Standard Deviations

Scenario	Case1	Case2	Case3	Case4	Case5	Case6
Mean	72.300	60.167	61.467	66.767	63.900	65.667
SD	8.655	7.571	8.170	7.417	8.450	7.563

On the other hand, in Case 2 and Case 3, we have observed the smaller numbers of the migrations. Figures 5 and 6 show the simulation results. When the governments get the larger number of agents at earlier steps of the simulation, they tend to be only winners. In Case 2, we have set the conditions that local government agents accept all the needs of the inhabitants. Therefore, the political strategies of the governments become to be similar to each other. In Case 3, because the local government agents have employed ISS, they have imitated the strategy, which wins the highest migrations of inhabitants. This has encouraged the uniform policies among the local governments.

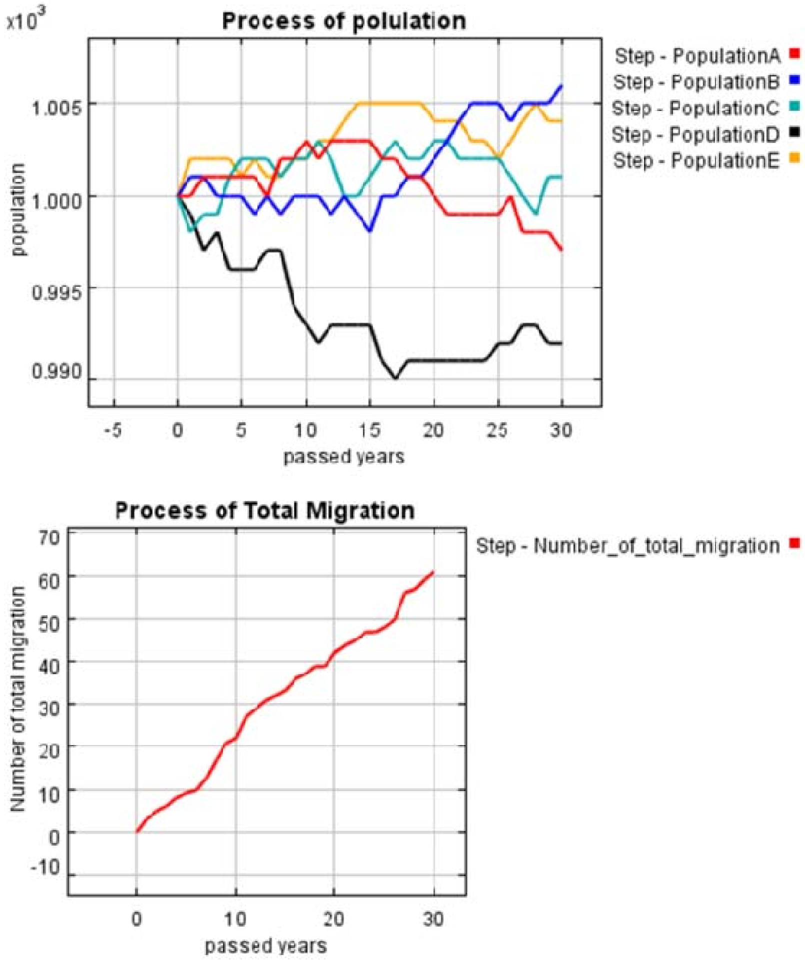

Figure 4. Results of Case 1

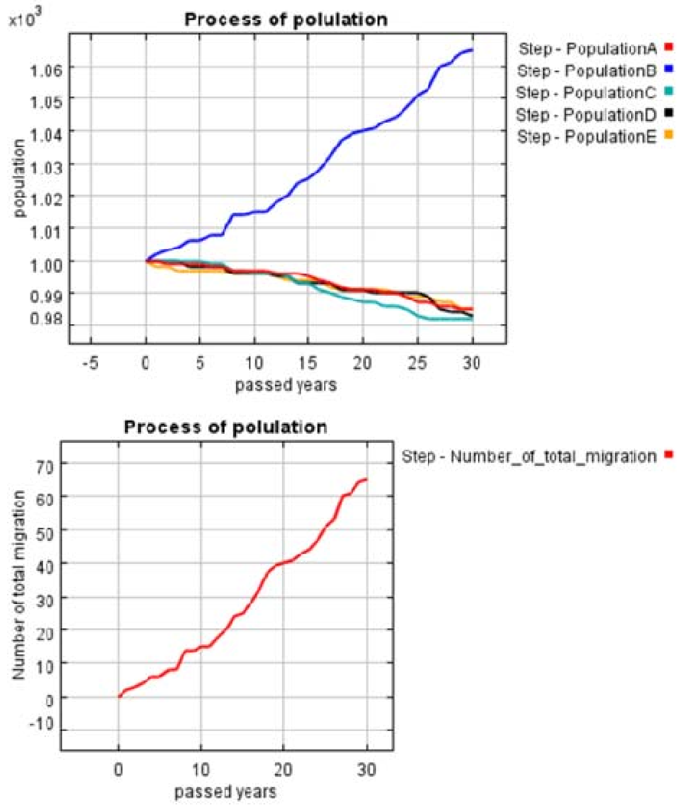

Figure 5 Results of Case 2

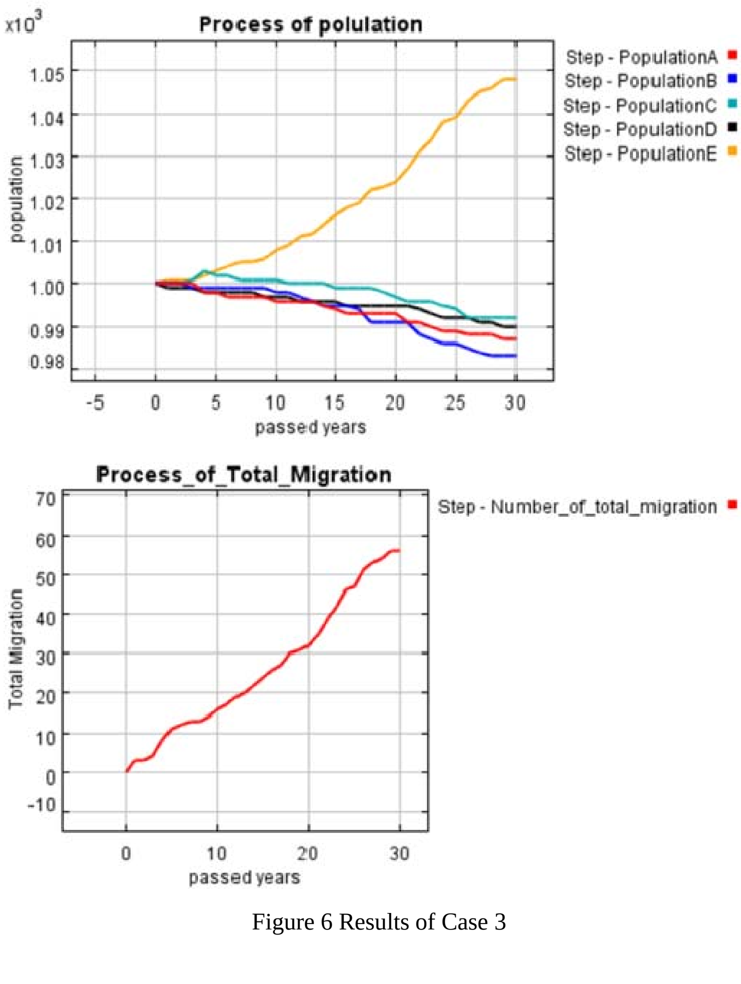

Figure 6 Results of Case 3

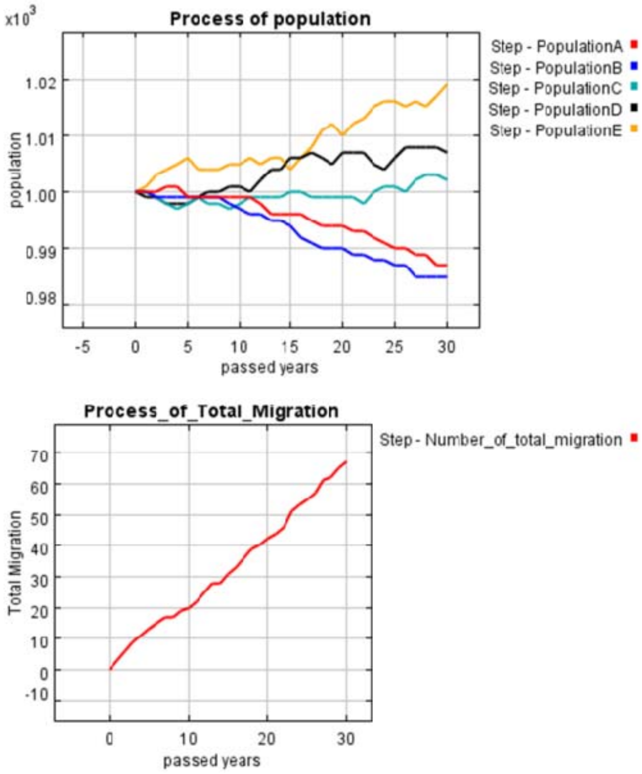

Figure 7. Results of Case 4

Table 3. Changes of Inhabitants in Each Area of Case 4

Scenario	lg_1(A)	lg_2(B)	lg_3(C)	lg_4(D)	lg_5(E)
Mean	-14.933	-9.667	-8.467	16.867	16.200
SD	3.982	9.072	10.708	8.123	7.341

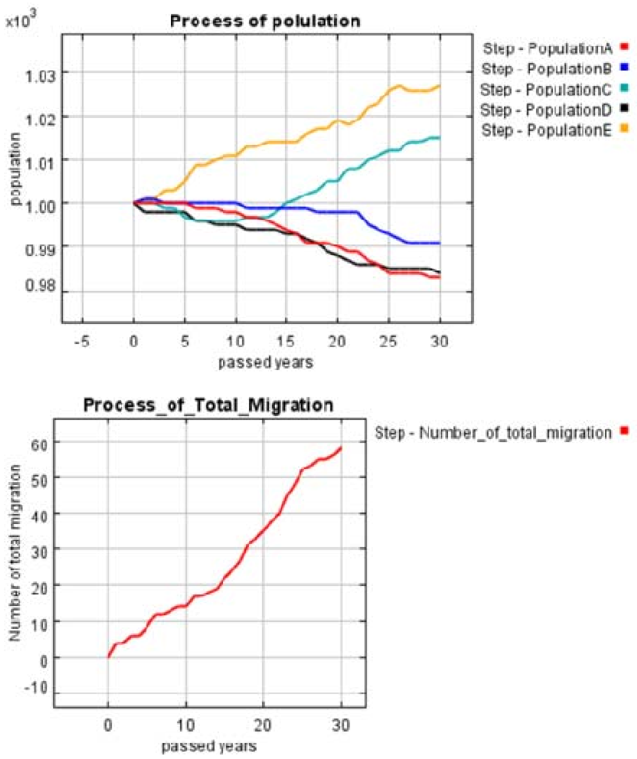

Figure 8. Results in Case 5

Table 4. Changes of Inhabitants in Each Area of Case 5

Scenario	lg_1(A)	lg_2(B)	lg_3(C)	lg_4(D)	lg_5(E)
Mean	-11.700	-13.667	-3.867	2.867	26.367
SD	10.373	6.5196	15.527	15.780	7.735

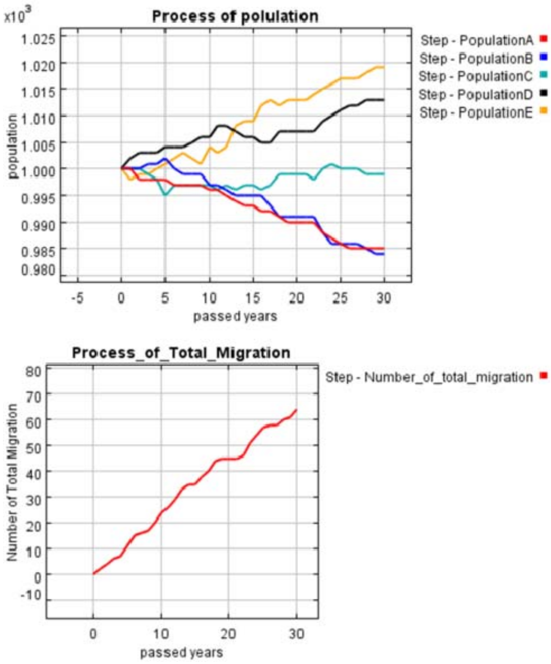

Figure 9. Results of Case 6

Table 5. Changes of Inhabitants in Each Area of Case 6

Scenario	lg_1(A)	lg_2(B)	lg_3(C)	lg_4(D)	lg_5(E)
Mean	-15.700	-15.200	-2.233	18.333	14.800
Variance	3.535	5.416	7.482	8.949	9.215

In Cases 1, 2, and 3, the average numbers of migrations of inhabitants tend to be smaller, when the simulation steps proceed, because in such cases, all the governments will take the same strategies.

In Cases 4, 5, and 6, in order to uncover which strategies would be better to get the larger number of inhabitants, we will show the statistical results how the number of inhabitants would change. In these cases, the strategies of the government agents are different from each other. From Figures 7, 8, and 9, government agents with FSS tend to have the larger numbers of inhabitants. The phenomena are able to be explained that i) inhabitants with biased preferences will migrate to the governmet with the unique policies of FSS, and that ii) governments with ISS will change the strategies to the better ones, where the governments take FSS, however, they have failed the strategies because the number of habitants have been already the smaller.

5. CONCLUDING REMARKS

This paper has presented a novel agent based simulation model to investigate the effects of “Voting with Feet” mechanisms proposed by Tiebout. The model includes local government agents, which determine budget policies about political services, and inhabitant agents, which makes migration decisions based on the service levels and tax systems of the governments. The simulation results are summarized as follows: 1) unique policies of each local government will results in the encouragement of migrations of inhabitants, and covergence of the policies of the governments discoureges the migrations; and 2) Cases with various strategies, the imitation service strategy will cause the decreases of inhabitants. These results suggest the deeper understandings about “Vote with Feet” mechanisms and the applicability of agent-based modeling to political decision making.

Future work related on the research includes 1) 4) validation of parameter settings, 2) the introductions of interactions among inhabitants on the decision making of migrations, 3) landscape analyses among various government policy scenarios, and 4) grounding the simulation reults to the real world phenomena.

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