A Comprehensive Micro Simulation of Gentrification

Cheng Liu, David O'Sullivan

University of Auckland
email corresponding author: cliu146@aucklanduni.ac.nz

1. Introduction

Gentrification is defined as "a process of socio-spatial change where the rehabilitation of residential property in a working-class neighborhood by relatively affluent incomers leads to the displacement of former residents unable to afford the increased costs of housing that accompany regeneration". Generally, there are two types of gentrification theories (Pacione, 2005): production-side (supply-side) explanations and consumption-side (demand-side) explanations. The former (Diappi & Bolchi, 2008; O'Sullivan, 2002; Tsang & Leung, 2011; Wu, 2003) emphasize the role of the state and developers in encouraging gentrification and of financial institutions providing funding. In the latter (Fontaine & Rounsevell, 2009; P. Torrens, 2001; P. M. Torrens, 2007), neighborhood change is a primary reason for the relocation of households. Semboloni (2008) presents a gentrification model based on a micro-economic theory (Alonso-Muth theory) of residential location incorporating both demand and supply sides, although this comes at the cost of simplicity. In our research, a simple CA-ABM model combining both supply and demand side theories is built. While the model is abstract it appears to capture important qualitative features of gentrification well enough to merit further exploration.

2. Three gentrification theories

2.1 Household Life Cycle Theory

Scholars (Gober, 1992; Levin, Montagnoli, & Wright, 2009; Pitkin, 1990) believe household life cycle factor (e.g. child bearing) exerts a vital influence on housing market dynamics, second only to economic factor (e. g. household income). Investigating the relationship between generational housing bubble and aging baby boomers in the U.S., Myers and Ryu (2008) further suggest that the baby boom increase in the adult age cohort has fueled urban sprawl and gentrification as well as escalating house prices. In this sense, as an important component of demand-side gentrification theory, it is valuable to identify the relationship between household life cycle and gentrification.

2.2 Housing Life Cycle Theory / Filtering Theory

Filtering is defined as "the dynamic of dwelling price and quality changes and households' associated moves" (Galster, 1996, p. 1800) and refers both to life-cycle processes of housing units (changes in their price, or quality) and to the behavior and responses of households (socioeconomic position of households, such as their income levels). Gray and Boddy (1979) add that household mobility and house turnover should be included in the filtering process.

2.3 Rent Gap Theory

"Rent Gap is the disparity between the potential ground rent level and the actual ground rent capitalized under the present land use…" (Smith, 1996, p. 65) Recognizing the vehement dispute about rent gap theory (Badcock, 1989; Bourassa, 1993; Clark, 1988; Hammel, 1999a, 1999b; Lees, Slater, & Wyly, 2008; Newman & Wyly, 2006; Smith, 2002; Sýkora, 1993), a more comprehensive framework including both demand and supply side is employed in our model, possibly offsetting the shortcomings of rent gap theory. The relationship of three theories is illustrated in Figure 1.

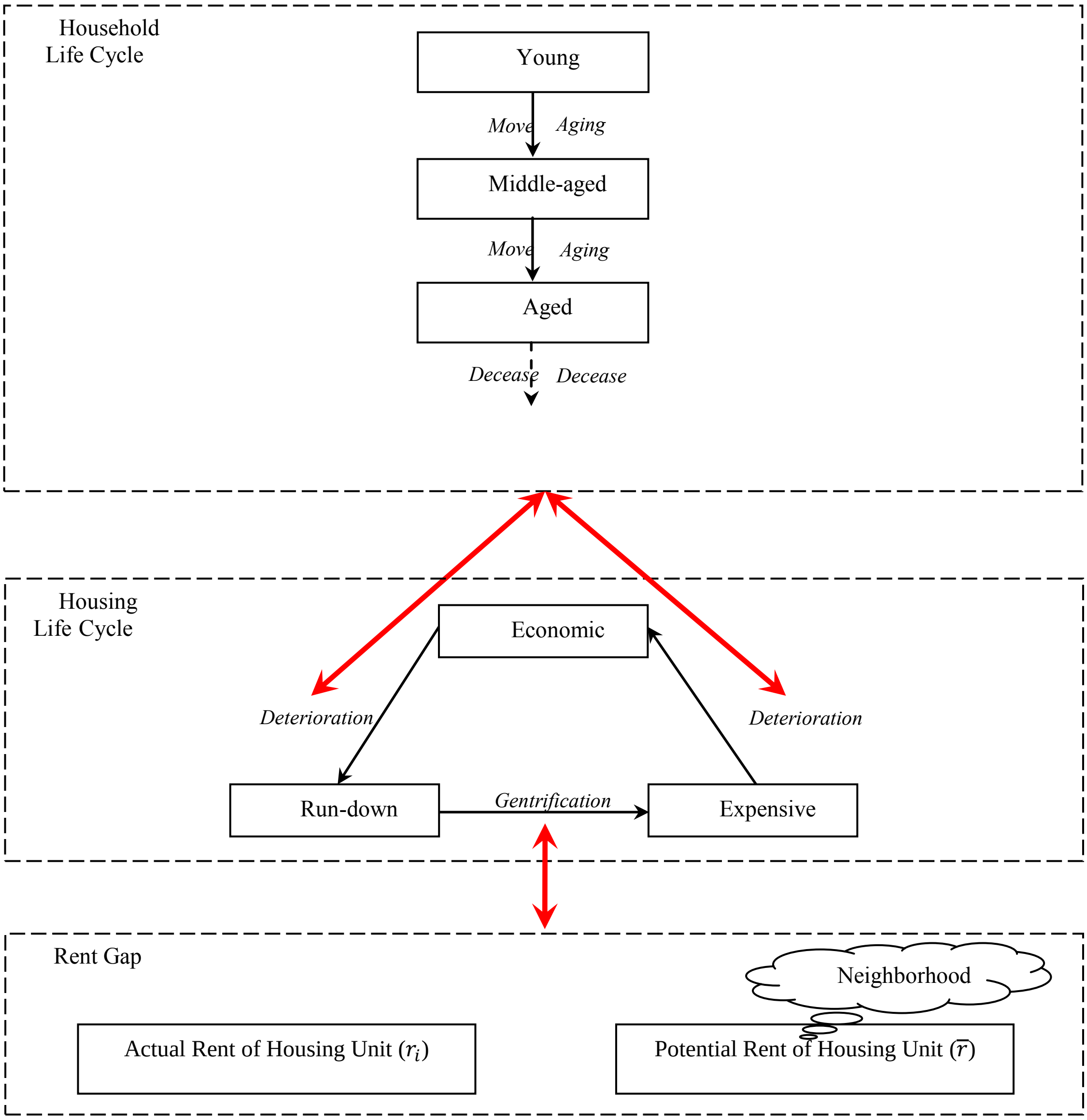

Figure 1: Relationship of Three Theories

3. Model description

There are two types of entities in the model: household and house, represented by agent and cell respectively. House deterioration rate is the key parameter to link housing life cycle and household life cycle and to combine supply-side and demand-side theories.

Household Type	Age	House Deterioration Rate
Young	[19, 30]	0.02
Middle-Aged	[31, 50]	0.005
Old	[51, 75+]	0.01

Table 1: State Variables of Household

Type	Standard	Target Resident
Run-Down	$r <= \mu_r - \sigma_r/2$	Young
Economic	$\mu_r - \sigma_r/2 < r <= \mu_r + \sigma_r/2$	Old
Expensive	$r > \mu_r + \sigma_r/2$	Middle-Aged

Table 2: House Categories[1]

Urban renovation is triggered once the condition below is satisfied. And value ranges of rent gap threshold and rent increment are listed in Table 3.

$$if\ \frac{1}{8} - \frac{r_i}{\overline{r}} \geq rent\ gap\ threshold, \qquad r_i = r_i + rent\ increment$$[2]

Parameter	Value
Threshold Rent Gap	[0.01, 0.12]
Rent Increment	100

Table 3: Ranges of Threshold Rent Gap and Rent Increment

4. Result and discussion

After running through the span of rent gap, three rent map patterns can be observed, representing three rent gap stages: Stage I (≤0.01), Stage II (0.02 – 0.075), Stage III (0.08 – 0.12) (NB: rent gaps excluded from three stages are regarded as transitional stages). Three sample values of rent gap in different stages are chosen: 0.01, 0.05 and 0.1. Dynamics of gentrification, spatial autocorrelation (Moran's I) and population of three kinds of households in a certain timespan are plotted in Figure 2. In gentrification, the black dashed line represents total gentrification times while the red solid one is for number of gentrification happened in a chain

---

[1] μ_r and σ_r are the mean and standard deviation of all housing unit rent respectively.

[2] r_i is the rent in position i and $\overline{r}$ is the average rent in r_i's Moor neighborhood.

reaction. In household, the green line represents population of young households, red for middle-aged and black for old.

Figure 2: Dynamics of Gentrification, Moran's I and Three Household Types in Three Stages

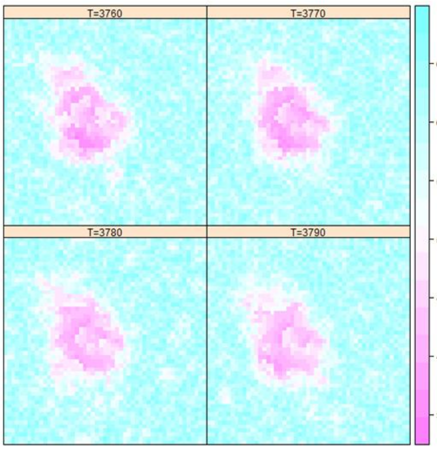

Figure 3: Rent Maps of Stage I

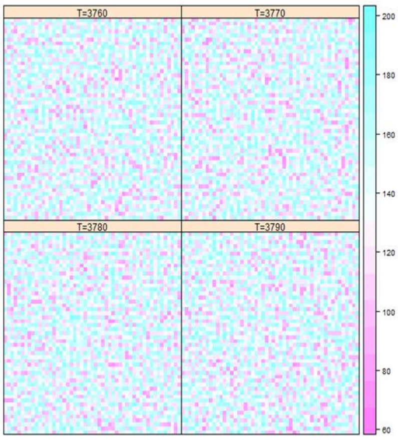

Figure 4: Rent Maps of Stage II

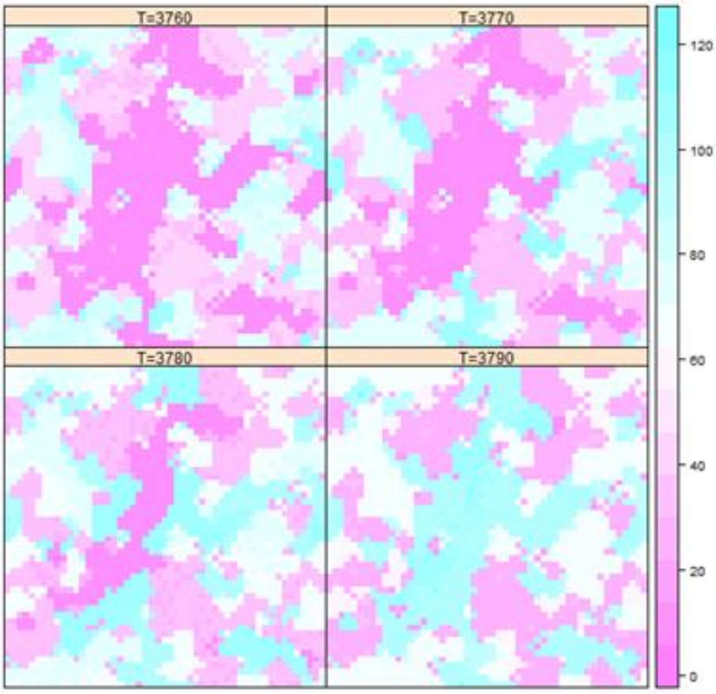

Figure 5: Rent Maps of Stage III

In Stage I, that all dynamics in the plot are apparently irregular suggests that the behavior of the model is stochastic. In Stage II, there are a larger proportion of isolated renovation incidents. The low Moran's I indicates that rent pattern is spatial stochastic, as is the household's population. As the rent gap increases, gentrification becomes regular and connected in

Stage III as the total gentrification line virtually overlaps line of the chain-reaction gentrification. Rent maps below in three stages show distinctive patterns. That three different urban patterns are generated just by tweaking the rent gap suggests that this abstract model has good potential for simulating urban development.

References

Badcock, B. (1989). An Australian View of the Rent Gap Hypothesis. *Annals of the Association of American Geographers, 79*(1), 125-145.

Bourassa, S. C. (1993). The Rent Gap Debunked. *Urban Studies, 30*(10), 1731-1744. doi: 10.1080/00420989320081691

Clark, E. (1988). The Rent Gap and Transformation of the Built Environment: Case Studies in Malmö 1860-1985. *Geografiska Annaler. Series B, Human Geography, 70*(2), 241-254.

Diappi, L., & Bolchi, P. (2008). Smith's rent gap theory and local real estate dynamics: A multi-agent model. *Computers, Environment and Urban Systems, 32*(1), 6-18. doi: DOI: 10.1016/j.compenvurbsys.2006.11.003

Fontaine, C., & Rounsevell, M. (2009). An agent-based approach to model future residential pressure on a regional landscape. *Landscape Ecology, 24*(9), 1237-1254. doi: 10.1007/s10980-009-9378-0

Galster, G. (1996). William Grigsby and the Analysis of Housing Sub-markets and Filtering. *Urban Studies, 33*(10), 1797-1805. doi: 10.1080/0042098966376

Gober, P. (1992). Urban Housing Demography. *Progress in Human Geography, 16*(2), 171-189.

Gray, F., & Boddy, M. (1979). The origins and use of theory in urban geography: Household mobility and filtering theory. *Geoforum, 10*(1), 117-127. doi: 10.1016/0016-7185(79)90017-4

Hammel, D. (1999a). Gentrification and land rent: A historical view of the rent gap in Minneapolis. *Urban Geography, 20*(2), 116-145. doi: citeulike-article-id:8227089

Hammel, D. (1999b). Re-establishing the Rent Gap: An Alternative View of Capitalised Land Rent. *Urban Studies, 36*(8), 1283-1293. doi: 10.1080/0042098992999

Lees, L., Slater, T., & Wyly, E. (2008). *Gentrification*. New York: Routledge.

Levin, E., Montagnoli, A., & Wright, R. E. (2009). Demographic Change and the Housing Market: Evidence from a Comparison of Scotland and England. *Urban Studies, 46*(1), 27-43. doi: 10.1177/0042098008098635

Myers, D., & Ryu, S. (2008). Aging Baby Boomers and the Generational Housing Bubble: Foresight and Mitigation of an Epic Transition. *Journal of the American Planning Association, 74*(1), 17 - 33.

Newman, K., & Wyly, E. K. (2006). The Right to Stay Put, Revisited: Gentrification and Resistance to Displacement in New York City. *Urban Studies, 43*(1), 23-57. doi: 10.1080/00420980500388710

O'Sullivan, D. (2002). Toward micro-scale spatial modeling of gentrification. *Journal of Geographical Systems, 4*(3), 251-274. doi: 10.1007/s101090200086

Pacione, M. (2005). *Urban geography: a global perspective* (2nd ed.). New York: Routledge.

Pitkin, J. (1990). Housing consumption of the elderly: A cohort economic model. In D. Myers (Ed.), *Housing demography* (pp. 174–199). Madison, WI: University of Wisconsin Press.

Semboloni, F. (2008). *Segregation and gentrification as emerging phenomena from the real estate market*. Paper presented at the 48th Congress of the European Regional Science Association, Liverpool.

Smith, N. (1996). *The New Urban Frontier: Gentrification and the revanchist city*. London and New York: Routledge.

Smith, N. (2002). New Globalism, New Urbanism: Gentrification as Global Urban Strategy. *Antipode, 34*(3), 427-450. doi: 10.1111/1467-8330.00249

Sýkora, L. (1993). CITY IN TRANSITION: THE ROLE OF RENT GAPS IN PRAGUE'S REVITALIZATION. *Tijdschrift voor economische en sociale geografie, 84*(4), 281-293. doi: 10.1111/j.1467-9663.1993.tb01770.x

Torrens, P. (2001). Can geocomputation save urban simulation? Throw some agents into the mixture, simmer and wait (Vol. Working Paper series: Publication 32): University College of London, Centre for Advanced Spatial Analysis.

Torrens, P. M. (2007). A geographic automata model of residential mobility. *Environment and Planning B: Planning and Design, 34*(2), 200-222.

Tsang, S. W., & Leung, Y. (2011). A Theory-Based Cellular Automata for the Simulation of Land-Use Change. *Geographical Analysis, 43*(2), 142-171. doi: 10.1111/j.1538-4632.2011.00817.x

Wu, F. (2003). Simulating Temporal Fluctuations of Real Estate Development in a Cellular Automata City. *Transactions in GIS, 7*(2), 193-210. doi: 10.1111/1467-9671.00140