Modeling Transformation in Neighborhood with Urban Redevelopment in Built-up Area of Tokyo Incorporating Effect of Interaction

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Abstract

In Tokyo most of spatial changes in urban areas have been brought by redevelopments of each sites conducted by individual circumstances, continuous redevelopments and these spatial changes can be found dispersedly in areas. Once a spatial change in a certain site appears in an area as a building, it will be contained in a built environment which involves a perception of atmosphere of the area by residents and visitors who enjoy urban space. Planners and designers take part in continuing spatial changes. Thus, interactions among redevelopments by transformation of neighborhoods can be assumed. Using Sarugaku-cho, Shibuya-ku Tokyo, as a targeted example, we try to describe interactions in existing urban areas focusing spatial changes and changes of usage of buildings incorporating utility of players with the method of discrete choice model. We introduced some index related to built environment and choice probabilities of other groups as explanatory variables into the model.

1. Introduction

It has been long since the concept of sustainability became one of important concepts in the field of urban planning. As Japan is one of the countries characterized by being in the era of declining birth rate and aging popu lation and the shrinking economy, sustainability of urban space is emphasized as an important concept, especially from the point of view of diversity and spontaneous processes of urban rejuvenation (Radvic. 2010) creating people's vibrant life and livability. Suggesting notabilities on argument of city planning Talen asserts that those notabilities all made the call for planners to look for ways to use the tools of planning to foster diversity (Talen, 2005). Radvic focuses on the role of gentrification in urban generation, organizing nuanced approach to understand complex phenomenon of urbanities targeting Tokyo (Radvic, et al. 2012).

In the Tokyo area, residential areas exist in urban areas, which locate in the periphery of central Tokyo and are composed of lots owned by individual owners. Such a characteristic resulted from the government policy called "one's own house policy" (Kikkawa, et al. 2007). In view of land tenure, number of land owners, especially in a large city area in Japan increased remarkably after the World War II. In Japan, the right to construct buildings in each site is presumed to be included in land ownership. As urban planning authority and municipalities have limited authority, market mechanisms are supposed to have strong influence to outcome of utilizing each land (Watanabe, et al. 2002).

Though there are general restrictions in usages and formation of buildings, basically spatial changes in the urban areas are brought by redevelopments of each sites and premise conducted by circumstances and motivations of individuals. Thus, in existing urban areas, continuous redevelopments which are supposed to meet needs of market and land owners can be found dispersedly in areas. Such repeated modifications to space can be translated that components of visual local environment are modified continuously. Once the spatial change in a certain site appeared in an area as a building, it will be contained in the built environment. That is to say, a spatial change is supposed to involve perception of the atmosphere of the area created by residents, planners and designers who might take part in the following spatial changes. Assuming market efficiency, utilization on the potential of site, we can point out that there are interactions among individual spatial changes and transformation of the visual local environment. These interactions of spatial changes in the modification

process can be observed as metabolic change in the existing urban areas. Individual sites can be regarded as a kind of cell composing the urban quarters. The condition in the existing urban residential area in Tokyo suggests the possibilities that quality of built environment can be improved by a frame of cooperative games among the cells in an area in lax urban planning and scheme. In this study, we intend to describe interactions between each spatial change and the transformation of urban spaces. Interactions will be indicated as explanatory variables of the discrete choice model with some index which focus on appearance in an area of street, and also incorporating interaction effect variables into nested choice model by defining choice probabilities of other group that was categorized by site area observed in residential map of 2011.

2. Overview of description in neighborhood changes and modification of urban spaces

In an aspect of neighborhood changes, many studies have focused on gentrification (Slater, 2006), relating to the rehabilitation of housing including the timing, cost and the type of renovation (Zuhai, 1998) from the point of view of contribution of residential development in aspect of local sustainability (Broomley, et al. 2005), and so on. But few researches are found which focus on physical situation of urban areas, such as spatial changes, modification of sites and premises, and appearance in visual local environment. In certain cases, the microscopic study focusing on changes in existing residential areas (Whitehand, et al. 1999) is found in which the relations between site modification and appearance in an area of street are not taken into account.

With regard to the building life cycle, the cycle is very short for cities in Japan compared to the cycle in North American and Western European cities. Basically spatial changes in each sites and premises are brought by circumstances and motivations of individuals, sometimes with modifications of sites. In others words, the cycle of modification in built-up areas is short, which may be a characteristic of existing urban areas in Tokyo.

Taking a general view of literature on individual redevelopment in existing urban areas in Tokyo, there is some research conducted with perspective of tendency in residential areas. For instance there are research on new detached dwellings and residents accompanied by land subdivision (Sakai, et al. 2006), investigation in describing actual condition of open space built up with apartment buildings (Suzuki, et al. 1990), describing modification of open space on street brought by redevelopment of apartment building

(Nam, et al. 2006), suggesting methodology to understand the changes in appearance quantitatively in the highly dense area in Tokyo (Min, et al. 2007). However, there are only few researchers who try to describe dynamics or to reveal mechanisms of urban transformations over a period of time in phenomenon targeting on appearance of an area on street with mathematical manners. Some researches with formularization of models are found (for example, Osaragi, et al. 2003), but those researches focus on sites exclusively. Thus, appearances of an area on street are not taken into account.

In this paper, we intend to describe interaction of the built environment in urban redevelopment with modification of sites by analyzing the existing built-up area in which redevelopments and spatial changes by individual circumstances in each sites and premise are conducted for economical efficiency. Assuming utility of players such as residents, planners and designers who might take part in the continuing spatial changes, the method of discrete choice model was incorporated. The multinomial logit model which is a popular modeling approach based on the discrete choice formulation pioneered by McFadden (McFadden, et al. 1978) is adopted for the description of the surveyed spatial changes. As we intend to describe interactions between each spatial changes and the quality of street spaces that people can share as the living territories, we introduced some indexes as explanatory variables of the model focusing on whole appearance in an area of street in the cases of spatial changes.

Many literatures that describe mechanisms of interactions in field of economics in aspect of social networks (Blume, et al. 2010) (Jackson, et al. 2008) are found. Fukuda and Morichi incorporated concept of social interaction into social determinants of transportation choice with aggregate share of referenced group assuming field effects (Fukuda, et al. 2007) based on the Brock-Durlauf model (Brock, et al. 2001). In our formularization, the concept of interrelated discrete choice in which mutual dependence are presumed in the aspect of decision making by Dranganska (Draganska. et al. 2008) was applied.

3. Research designs

In this study, a survey of spatial change in Sarugaku-cho, located on the western edge of Shibuya-ku Tokyo (Fig. 1) was conducted, that consist of "Daikanyama" area. Daikanyama a is well-known popular neighborhood for shopping and its lively atmosphere. It is an area with a fashionable atmosphere and is, in large part, a residential neighborhood nowadays.

Hillside Terrace (Fig. 2) is one of the most famous buildings in Daikanyama designed by architect Fumihiko Maki. It was planned for the development of residential and commercial space in several phases. The first phase of the project was conducted in 1967, then the project was continued in several stages till 1992, and it is regarded as a great case study in urban development in collaboration with an architect and an owner of the lands, the Asakura family. Maki remarks the Asakura family as the best partner who would take time and not look for instant profit but had farsighted view of retaining the land and creating a place where they could continue to live comfortably for generations (Maki, 1992). Without Maki and Asakura's project, it is hard to imagine that such a favorable development of neighborhood in Daikanyama happened. However, we can fine other lively neighborhood spreading out with different atmosphere around Hillside Terrace. We feel sophisticated atmosphere around Hillside Terrace. Walking through Daikanyama, we feel a bit like walking through a maze in small streets. We find the scale of streets and alleys are small, filled with many shops and cafes, which brings casual yet fashionable atmosphere of neighborhood.

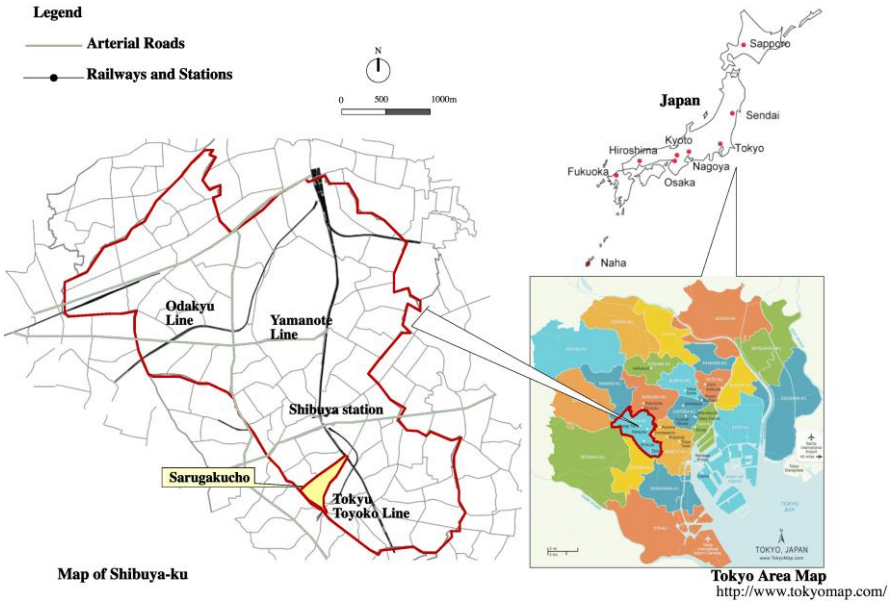

Fig. 1. Location of Sarugaku-cho, Shibuya-ku,Tokyo Japan

Fig. 2. Hillside Terrace

In advance of analysis of Sarugaku-cho, an interview with Fumihiko Maki was carried out, which we found some profound implication for the following study. After making a basic analysis on the data of the survey in Sarugaku-cho, we made a model definition to describe mechanism and process of redevelopments and spatial changes revealing interactions of the buildings in the neighborhood. Concept of payoff in game theory can be found in the choice of patterns in spatial changes and changes of usage of buildings. These patterns can be presumed as alternatives of the utility function. Supposing the 'players' who have some interest each spatial changes and changes of usage of building as land owner, designer, developer, constructor etc. we can assume that they make decisions on alternatives in individual circumstances and motivations, sometimes accompanied modifications of sites. Not only the individual condition of each site and premises but also the potential of neighborhood, convenience, livable atmosphere of resident, spatial changes in other sites, condition of road and street-scape in neighborhood are assumed to affect in these decision making. In this point of view, agents that consist of local neighborhood act and make choices considering behavior of other agents.

In this paper, we intend to describe interaction among choices of spatial changes in relatively large site and that of the generally sized site in Sarugaku-cho area introducing concept of interrelated discrete choice game in which mutual dependence is presumed. Definition of nested model in which choice probabilities of other group are incorporated as explanatory variables is conducted. It describes transformation of neighborhood with individual urban development as a set of agents' behavior.

4. Basic analysis

4.1. Literature review of hillside terrace and summary of interview

There is an abundant amount of literature on community development and neighbor-hood changes in the context of Hillside Terrace brought by Asakura family and Fumihiko Maki. Maki is appreciated as an excellent architect Asakura family is also recognized as foresighted land owner in suggesting project of the building, consisting stores, introducing cultural activity, and so on. Maki mentions his slow steady process and mutual trust among owners of land and designers and his slow determination and sense of responsibility in what they can produce for the neighborhood upon their discussion (Maki, 1992). He remarks that they couldn't imagine neighborhood changes in Daikanyama in a quarter of a Century maintain a quarter of the long-term vision of the areas. Iwahashi praised Hillside Terrace for establishing a kind of brand creating urban spaces with high quality and the dynamism of urban cultures produced by the people related with Hillside Terrace (Iwahashi, 1995). At the same time he argues that they cannot find any other urban spaces in which such a good positive cycle was realized under the condition that the great project and the neighborhood are being influenced by each other. Hillside Terrace can be regarded as symbol of the areas but they can find other lively urban spaces just as the alternative urban spaces in the matured cites around the world.

From the point of view of landscape, Maki remarks as follows; The landscape that Hillside Terrace is centered on providing public spaces, including the sidewalk in front of site…There are certainly limits to the types of spaces that an architect or an urban designer can provide. However, spaces can enter into relationships with parts of the city impinging on the site to create landscapes many people can share (Maki, 1994).

Based on these reviews, an interview with Maki targeting relation between Hillside Terrace and neighborhood transformation with redevelopments was executed on June 2012. Compiled summary is as follows.

In Hillside Terrace Project buildings and landscapes were designed by an architect creating "the landscape of time" in each period referring to design of the project itself in the flow of time. I don't think that we were influenced much from neighborhood, but perhaps we can say that the project has brought the impact on neighborhood in establishing a kind of brand of the area. As we designed residential units as spaces for residential, it was surprising for us that residential units were used as working place. Tokyo possesses few standards of urban form. In this condition, perhaps we can say that favorable neighborhood transformation might be conducted with accumulation of the spaces designed under concept of provid-

ing public spaces or common spaces by architects as a common opinion. But I don't think we can find a universal method. When a space appeared in a certain form, there is a possibility that people use space innovatively and create a new usage of space which might be perceived as a good model in the following spatial changes.

4.2. Basic analysis on spatial changes and site modification in surveyed area

As an outcome of the survey on spatial changes in Sarugaku-cho, spatial changes brought by redevelopments of each sites and premise and changes

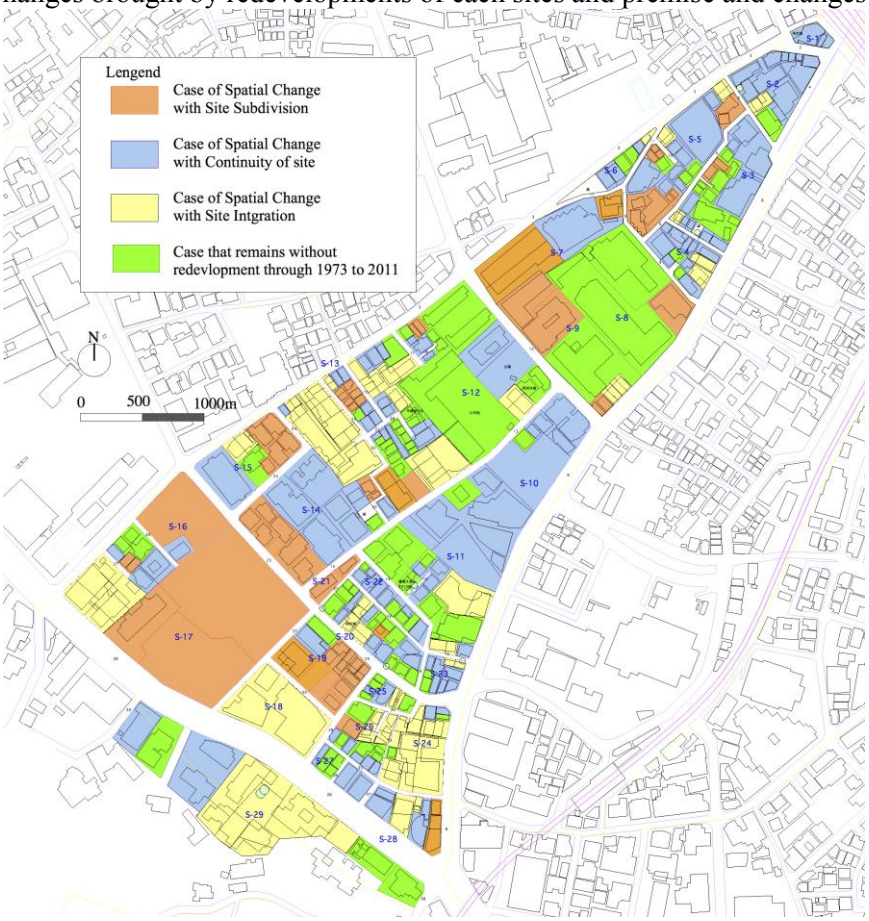

Fig. 3. Distribution of spatial changes focusing on pattern of site modification from 1973 to 2011 in Sarugaku-cho observed in Zenrin residential map

of usage of building in each sites were listed with information on each case, for instance site area, period of the spatial change, residential type, width of each site abutting on street, and so on. Those data were acquired by comparing each city block width housing maps of Shibuya-ku, published by Zenrin, version of 1973, 1977, 1981, 1986, 1991, 1996, 2001, 2006 and 2011 (Fig.3). At the same time we made field reconnaissance of all the streets of Sarugaku-cho, learning from the appearance of each building and site, we observed patterns on the usage of buildings and in modification in each site as follows.

Pattern on usage of building
- Detached house
- Apartment house
- Commercial use (office and shops)
- Complex of residential and commercial use

Pattern on modification of site:
Case of subdivision of site
Case of continuity of site
Case of integration of sites
Case without redevelopment

Then classification of patterns was conducted as follows, taking chronological changes of urban space into consideration, sorting all sites and buildings in Sarugaku-cho area with above-mentioned focal point, overlaying view points of the appearance on the street in each site and transformation of usage on advantage of redevelopment. Figure.4 indicate typical appearances of these patterns.

a-1 Redevelopment as residential area in case of site subdivision without changes of usage of building
a-2 Redevelopment as residential area in case of site subdivision from office or commercial use
a-3 Redevelopment as commercial usage area in case of site subdivision without changes of usage of building
b-1 Redevelopment as residential in case of continuity of site without changes of usage of building
b-2 Redevelopment as residential in case of continuity of site from office or commercial use
b-3 Redevelopment as commercial usage in case of continuity of site from residential use.
b-4 Redevelopment as commercial usage in case of continuity of site without changes of usage of building
c-1 Redevelopment as residential in case of integration of sites without changes of usage of building

c-2 Redevelopment as residential in case of integration of sites from office or commercial use
c-3 Redevelopment as commercial usage in case of integration of sites from residential use.
c-4 Redevelopment as commercial usage in case of integration of sites without changes of usage of building
d-1 Remains without redevelopment through 1973 to 2011 as residential
d-2 Remains without redevelopment through 1973 to 2011 but change from residential to commercial use has observed

Fig. 4. Typical appearances of patterns on spatial changes, site modification and transformation of usage of each building

d-3 Remains without redevelopment through 1973 to 2011 in commercial use

Overlooking the neighborhood change in aspect of spatial changes and changes of usage of buildings in Sarugaku-cho, the illustration is made to indicate frequency of patterns and observed total site areas in spatial changes and changes of usage of buildings observed on the map from 1973

to 2011 in each group divided according to each site's areas focusing on site modification patterns (Fig. 5 and Fig. 6). Site modification can be categorized into three patterns, site subdivision (as Sub in Fig. 5 and Fig. 6), continuity of site (as Co in Fig. 5 and Fig. 6) and integration of sites (as Int in Fig. 5 and Fig. 6). Spatial changes and changes of usage of buildings can be classified in four patterns, remain as residential use(as R in Fig. 5 and Fig. 6), changes of usage from residential to office or complex use(as RtoOC in Fig. 5 and Fig. 6), changes of usage from office or complex use to residential (as OCtoR in Fig. 5 and Fig. 6) and remain as office or complex use (as OC in Fig. 5 and Fig. 6). The cases observed has remained without redevelopment through 1973 to 2011 as expressed as 'Non' in Figure. 5 and Figure. 6. Bars in the left side indicate frequency of the cases in each patterns in Fig. 5, and total site areas of each patterns in Fig. 6.

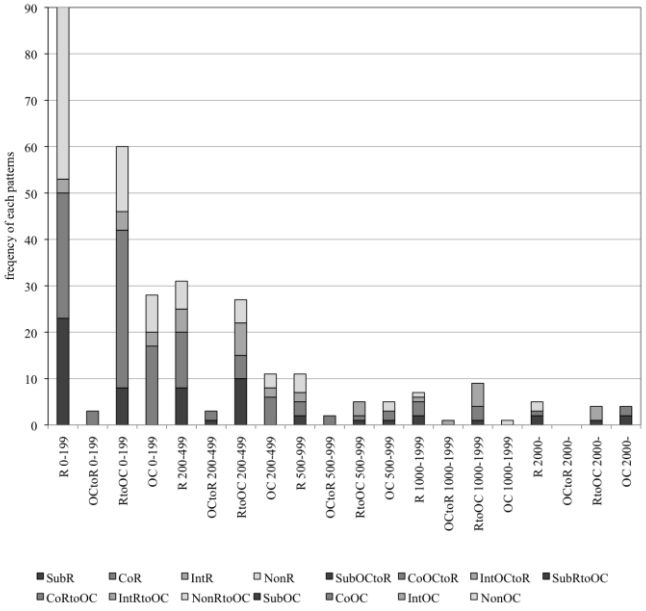

Fig. 5. Frequency of patterns in spatial changes observed from 1973 to 2011 according to the size of areas in each sites

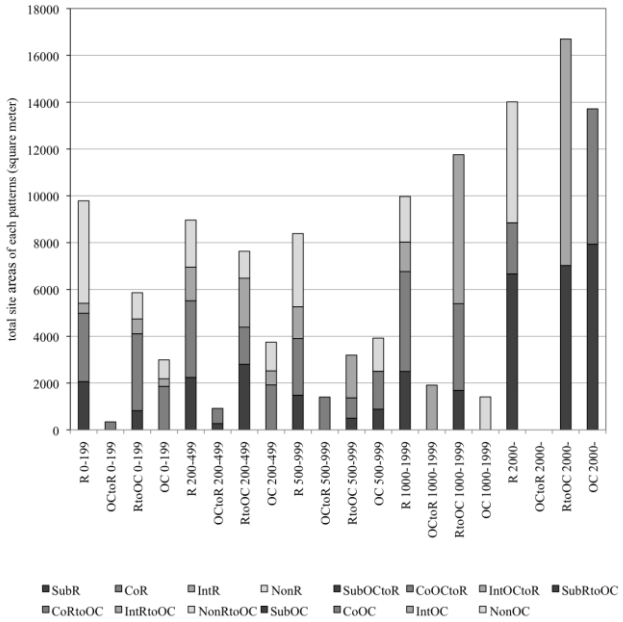

Fig. 6. Total site areas in spatial changes observed from 1973 to 2011according to the size of areas in each sites

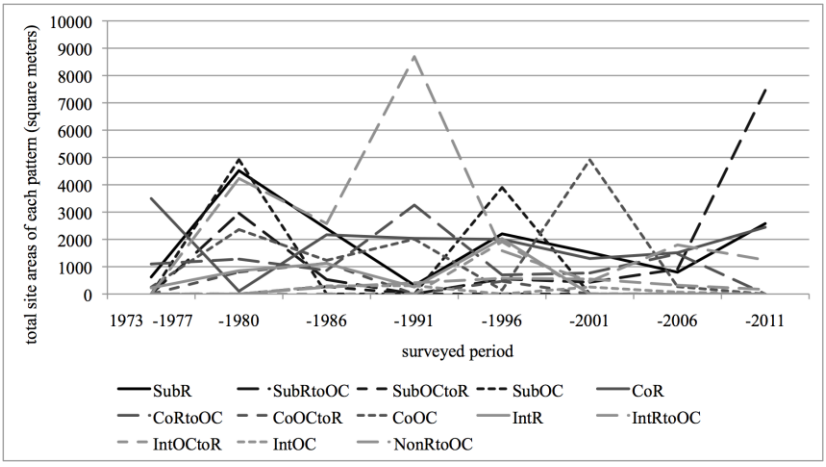

Fig.7. Total site areas of each pattern in site modification, spatial changes and changes of usage of buildings according to the timeline

4.3. Analysis on spatial changes pattern from viewpoint of timeline

To understand the mechanism of neighborhood transformation, the chronological aspect is important. Figure. 7 indicates aggregated total site areas of each pattern in each surveyed period. We can find correlation in several pat-terns, for instance CoRtoOC and IntRtoOC, IntR and IntOCtoR and SubOCtoR and CoOCtoR.

4.4. Analysis of configuration in usage of buildings focusing on street

Daikanyama Kyu-Yamatedori where Hillside Terrace and other newly developed buildings locate and compose sophisticated street-scape and Yawata-dori where major commercial complex locate are introduced as popular streets, but when people walk around the area, they can find many small streets and alley with attractive small cafes, boutiques and other stores interspersed among tranquil residential area. This kind of surprising seems to hold fascination for visitors in Daikanyama neighborhood.

In Japan floor area ratio is established by municipal in each areas but there is also regulation that maximum floor area ratio is restricted depending on width of street on which the site abuts. Along the narrow alley floor area ratio of the sites are limited in low rate, conditions for construction are not sufficient compared with those of the sites abutting on major street, urban area along narrow alley tend to be dense with small old residential buildings regarded as problematic causing that superannuated buildings remain without redevelopment. But from field survey we found that there are plenty of examples converted into stores and offices without extension nor destroying, making a good, old and homely atmosphere. Thus we made analysis focusing on configuration of usage of buildings on the street on which each site abut.

Though the data were acquired in viewpoint from each site in each period, when we aggregate the data across the streets we can get another aspect of understanding neighborhood transformation. In each surveyed period, the length along the street on which each site abut were aggregated according to four patterns on usage of buildings, residential apartment building, detached house, parking lot or vacant space without building and the building in commercial use or in complex use of commercial and residential. Assuming the major pat-tern of the street in each period account for characteristic of each street, we made cluster analysis in ward method, on those data. Figure.8 was illustrated with categorizing street in aspect of

trans-formation in configuration of usage of buildings along the street according to the cluster analysis.

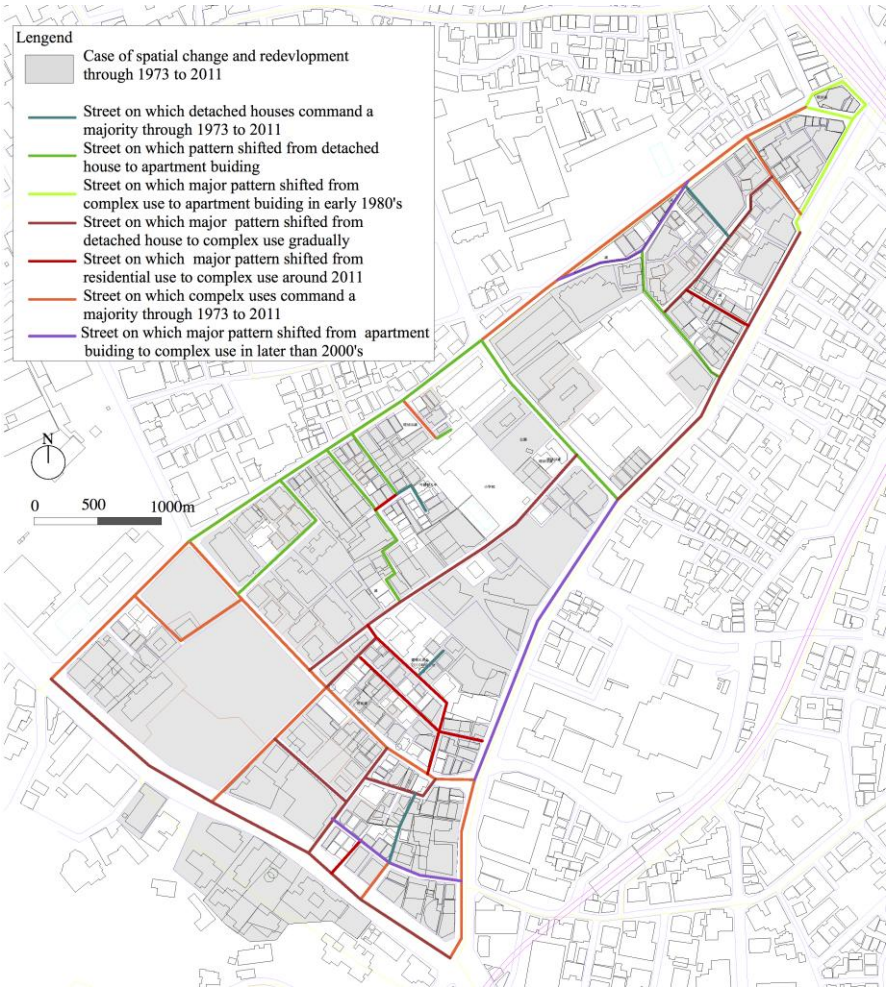

Fig. 8. Street in Sarugaku-cho categorized in aspect of transformation in configuration of usage of buildings

5. Model definition and estimation

In order to describe mechanism and process of urban redevelopments and spatial changes, we tried to make model definition and estimation. In aspect of processes of planning, each redevelopment conducted by individual

circumstances and motivations seems to be made of the site and the built environment. For instance if the permitted floor area ratio has changed into higher rate in revision of local regulations concerning architectural planning, it will be profitable to developers. The Concept of payoff in game theory can be found in the choice of building type, The appearance on the street, and so on. Thus spatial changes patterns can be presumed as alternatives of the utility function. Multinomial logit model which is a popular modeling approach based on the discrete choice formulation is adopted for the description of the surveyed spatial changes and changes of usage of buildings.

The probability that a spatial change pattern i is chosen by the decision maker n in each site is defined as $P_n(i)$, where U_{in} is the utility that decision maker n obtain from the physical attributes of the site and neighborhood.

$$U_{in} = V_{in} + \varepsilon_{in} = \Sigma \beta_k x_{kin} + \varepsilon_{in} \tag{1}$$

$$P_n(i) = \frac{exp V_{in}}{\sum_{j=1}^{J} exp V_{jn}} \tag{2}$$

In the above equation, x_{kin} is the a vector of observed attributes for the alternative i of the decision maker n, β is a vector of the model parameters to be estimated,εis the error term which represent unobserved effects assumed to be independently, identically distributed as gumbelle distribution with extreme value.

Explanatory variables were listed with following observation. While urban planning system in western countries consists of two layers, that is general city planning as master planning (such as GP, SP, FP, SD) and official planning as local level planning (such as Zoning, LP, BP, POS) which regulate land use and form of buildings of each individual developments, urban planning system in Japan is characterized with many layers without concrete scheme. As the rules for individual developments and spatial changes which regulate land use and form of buildings in detail are not included, it is hard to find the concept of forecasting urban changes in urban planning system (Koizumi, 2004). Usage of land and building, form and design of building are determined by regulations concerning building form so called restriction for group in the Building Standard Act and other local regulations. These regulations are applied under attribution of each site, condition of the road on which the site abut and authorized use district. Regulations for building form are designated out of constraints from urban planning system, changes in these regulations aiming economical revitalization are observed frequently. As previously mentioned in chapter 1, market mechanisms are supposed to have strong influence on outcome

of utilizing each site. Accordingly, amenities of local areas related to residential needs and satisfactions of targeting inhabitants are valued. Developers and designers are supposed to optimize potential of site and surrounding environment, maximizing volume of building for sale or for rent, developing their ideas for market efficiency referring residential trends in local areas. In this point of view, attribution of sites, blocks and composition of buildings on streets act on decision making by players on spatial changes.

Attribution of each site and premises which has effect on feasible planning for spatial changes such as site area for the project, permitted floor area ratio, width of the abutting on the street, and others are assumed to be explanatory variables. Furthermore, to incorporate chronological aspect that elements of built environment that past redevelopment provided as the

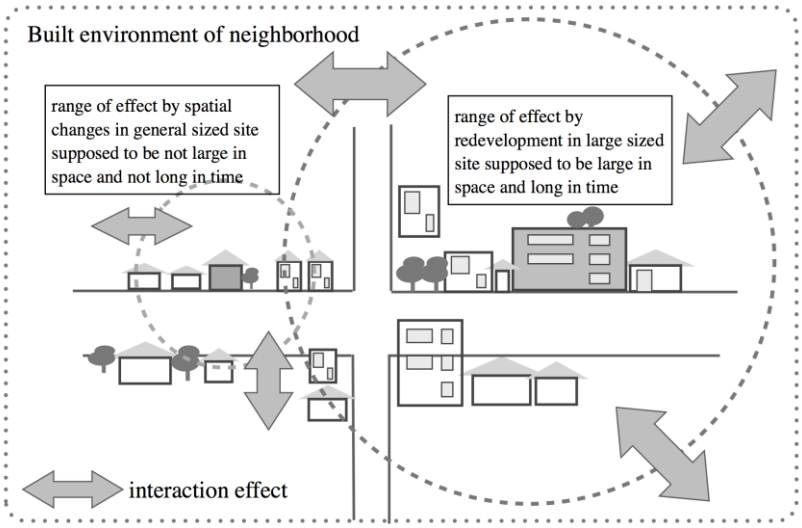

Fig. 9. Framework of hypothesis in interaction effect on the model

street-scape affect proceeding redevelopments, we tried to set up these matters as explanatory variables referring to our previous studies (Kokubun, et al. 2011a) (Kokubun, et al. 2011b).

Individual sites do not exist independently but they belong to an urban areas and share atmosphere of local visual environment. Regarding each site as an agent we can assume utilization of built environment in each agent's behavior that is to say urban redevelopments, spatial changes and changes of usage of buildings. In case of small site or land owner of small size, alternatives in changes might be limited comparing those of large site, owners of large lands, land owned by corporations and so on. In the case

of large redevelopment, developers and designers consider carefully about not only attributes of sites and location but also economic performance, lifestyle of targeting consumers, economic condition and business environment. From viewpoint of neighborhood environment those redevelopments create impact and influence on its areas. Redevelopment including changes of usage of building in small site might be affected by those large scaled redevelopments. Furthermore, also large redevelopments are influenced by neighborhood atmosphere like liveliness of people in the neighborhood and definite spatial usage in the neighborhood, which means that large redevelopment also affected by small spatial changes or changes of usage of buildings. We should take into account the differences among those influences in aspect of spatial range and time range. Framework of hypothesis in interaction effect on the model is shown in Figure. 9.

From the analyses in former section, we assumed that there are differences in patterns of redevelopment or changes of usage as behavior of each sites among sites of which area is over 1000 square meters at the time of 2011 and other sites that are smaller than 1000 sq meters. Interactions between these groups were considered in model definition as to incorporate choice probabilities of other group as explanatory variables. From these points of view, we made definition of the model as follows.

Formularization of Spatial Changes Pattern Model for large sized sites, where Pr(x) indicates choice probability in other groups,θis parameter which indicate to what extent the choice probability of other group affects. As mentioned above, spatial range and time range are considered in definition of Pr(x).

$$
\begin{aligned}
V_{li=1} &= \beta_3\, bl_{li} + \beta_4\, wd_{li} + \beta_1\ (\text{Constant}) \\
V_{li=2} &= \beta_5\, fr_{li} + \beta_6\, wd_{li} + \beta_7\, stw_{li} + \theta_{exr}\Pr_s(exr) + \beta_2\ (\text{Constant}) \\
V_{li=3} &= \beta_8\, siw_{li} + \beta_9\, rtcd_{li} + \beta_9\, mustc_{li} + \theta_{chu}\Pr_s(chu) \qquad (3)
\end{aligned}
$$

i= Patterns in spatial change and usage of building

1: Remains as former condition without spatial change
2: Spatial changes into building in usage of exclusively residential
3: Spatial changes into building in complex use

β_{li} =Parameter

bl_{li} = Area of block (m^2)/10000
wd_{li} = Dummy variable as location within five minutes walking from Daikanyama station
fr_{li} = Floor area ratio (m^2)/100
stw_{li} = Width of the street on which the site abutting (m)
siw_{li} = Width of the abutting on the street (m)
$rtcd_{li}$ = Dummy variables of change in floor area ratio by municipal during the surveyed period
$mustc_{li}$= Dummy variables when major pattern in usage of building of the street was complex use on the previous period

Formularization of Spatial Changes Pattern Model for small sized sites

$$
\begin{aligned}
V_{si=1} &= \beta_5 bl_{si} + \beta_6 scc_{si} && + \beta_1 \text{ (Constant)} \\
V_{si=2} &= \beta_7 sa_{si} + \beta_8 wd_{si} && + \beta_2 \text{ (Constant)} \\
V_{si=3} &= \beta_9 nst_{si} + \beta_{10} scu_{si} + \theta_{comp} \Pr_l(comp) && + \beta_3 \text{ (Constant)} \\
V_{si=4} &= \beta_{11} mustv_{si} + \beta_{12} siw_{si} && + \beta_4 \text{ (Constant)} \\
V_{si=5} &= \beta_{13} stw_{si} + \beta_{14} sci_{si} && (4)
\end{aligned}
$$

i= Patterns in spatial change and usage of building and site modification
1: Remains as former condition without spatial change
2: Spatial changes into building in usage of exclusively residential with continuity of site
3: Changes of usage of building into complex use without spatial changes and spatial changes into complex use with continuity of site
4: Spatial changes into building in usage of exclusively residential with modification of site as subdivision or integration
5: Spatial changes into building in complex use with modification of site as subdivision or integration

β_{si} =Parameter

bl_{si} = Area of block(m^2) /10000

scc_{si} = Ratio of total width of the site which spatial change occurred with continuity of site in previous period beyond total street length

sa_{si} = Area of site(m^2) /1000

wd_{si} = Dummy variable as location within five minutes walking from Daikanyama station

nst_{si} = Number of street on which the site abut

scu_{si} = Ratio of total width of the site which usage of building has changed without site modification in previous period beyond total street length

$mustv_{si}$= Dummy variables when major pattern in usage of building of the street was parking lot or vacant space on the previous period

siw_{si} = Width of the abutting on the street(m)

stw_{si} = Width of the street on which the site abutting(m)

sci_{si} = Ratio of total width of the site which spatial change occurred with integration of site in previous period beyond total street length

Estimation was executed with the method of pseudo maximum likelihood estimation suggested by Aguirregabiria (Aguirregabiria, 2004). It was conducted using function for generalized optimization of free software R. Table 1 shows the result. As some variables in certain choice were not significant, we have to explore possibility to find more fitting models. The result shows that some variables indicating effect of former spatial changes are significant, and interaction effects are also significant.

Table 1. Estimation results of the Multinomial Logit Model on spatial changes and changes of usage of buildings

Pattern of Spatial Change	Large sized site Variables	Parameter	t-stat		Pattern of Spatial Change	Small sized site Variables	Parameter	t-stat	
Remains as fomer condition without spatial change	Constant	2.793	5.13	**	Remains as fomer condition without spatial change	Constant	4.184	17.03	**
	Area of block /10000(bl_{li})	0.396	1.17			Area of block /10000(bl_{si})	0.255	1.88	
	Dummy variable as location within five minutes walking from Daikanyama station(wd_{li})	1.135	3.14	**		Ratio of total width of the site which spatial change occurred with continuity of site in previous period beyond total street length(scc_{si})	−1.497	−2.20	**
Spatial changes into building in usage of exclusively residential	Constant	−1.658	−1.09		Spatial changes into building in usage of exclusively residential	Constant	0.403	1.19	
	Floor area ratio/100(fr_{li})	0.689	1.54			Area of site /1000(sa_{si})	0.858	1.37	
	Dummy variable as location within five minutes walking from Daikanyama station(wd_{li})	1.819	2.30	**		Dummy variable as location within five minutes walking from Daikanyama station(wd_{si})	0.382	1.43	
	Width of the street on which the site abutting(stw_{li})	−0.824	−1.12		Changes of usage of building into complex use without spatial changes and spatial changes into complex use with continuity of site	Constant	0.455	1.20	
Spatial changes into building in complex use	Width of the abutting on the street(siw_{li})	−0.314	−3.25	**		Number of street on which the site abut(nst_{si})	0.241	1.37	
	Dummy variables of change in floor area raio by municipal during the surveyed period($rtcd_{li}$)	3.670	4.93	**		Ratio of total width of the site which usage of building has changed without site modification in previous period beyond total street length(scu_{si})	0.858	1.66	
	Dummy variables when major pattern in usage of building of the street was complex use on the previous period($mustc_{li}$)	0.265	0.79		Spatial changes into building in usage of exclusively residential with modification of site as subdivision or integration	Constant	−1.663	−3.05	**
						Dummy variables when major pattern in usage of building of the street was parking lot or vacant sapce on the previous period($mustv_{si}$)	0.382	1.53	
						Width of the abutting on the street(siw_{si})	0.241	2.77	**
					Spatial changes into building in complex use with modification of site as subdivision or integration	Width of the street on which the site abutting(stw_{li})	2.528	2.73	**
						Ratio of total width of the site which spatial change occurred with integration of site in previous period beyond total street length(sci_{si})	3.437	2.14	*
Parameter of Interaction	Choice probability of small sized site Spatial changes into exclusively resiidntial $P_{li}(exr)$	−2.221	−0.33		Parameter of Interaction	Choice probability of large sized site Spatial changes into complex use $P_{si}(comp)$	20.435	2.76	**
	Choice probability of small sized site Change of usage of building $P_{li}(chu)$	171.208	3.82	**					
	Number of observations	2097							
	Initial log-likelihood	−4264.99							
	Final log-likelihood	−1186.63							
	Rho-squared	0.722							
	Rho-bar-squared	0.715							

** significant at α=0.01 * significant at α=0.05

6. Concluding remarks

Transformation on visual local environment, condition of built environments, and livability of neighborhood in existing urban area conducted by redevelopment in each site by individual circumstances and motivations due to the tenure of lands can be considered as a distinguished feature in Tokyo compared with the situation in Western European cities. Each redevelopment in an area with certain planning and design are conducted individually, once it appeared in an area as a building, it is contained in the built environment which involves perception of atmosphere of the urban area by planners and designers of following spatial changes. This interaction in urban modification process can be observed as metabolism of spatial changes in existing urban area. In aspect of revitalization of built-up areas it might be necessary for the neighborhood to be provided large development with good design and intention in adequate location and timing but not sufficient.

From analysis and model estimation in this study, we suggest that interactions occur not only between behavior of individual sites and built environment but also among individual sites in neighborhood. Seeking for sustainability on existing urban areas, we think that it is important to incorporate the idea with this kind of interactions into urban planning method. In this study, we made model definition assuming utility in the choice of pattern in spatial changes for describing interaction between built environment and redevelopment and neighborhood transformation in existing urban areas with simple method. Quality of built environment, vigorous and lively neighborhood are suggested in positive growth cycle with continuous spatial changes of areas. Further investigation in this kind of cooperative game model on redevelopment in built-up area not only on areas known as livable neighborhood such as Daikanyama, but also on other general existing urban areas are needed.

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