Simulation Analyses on Jane Jacobs' City Diversity Requirements by Using Downtown Dynamics Model

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Abstract

In recent years, in the centers of provincial cities in Japan, the so-called doughnut syndrome is becoming a problem. Using DDyn, a prototype version of the Down-town Dynamics Model newly developed by the authors, the research conducted simulations for the sustainability of downtown commercial districts and analyzed the results. In addition, by comparing with the four conditions for city diversity formerly advocated by Jane Jacobs, the research examined the implications of the DDyn simulations.

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1. Research Background and Objectives

In recent years, in the centers of provincial cities in Japan, the so-called doughnut syndrome is becoming a problem with the flight of the residential population from city centers and the consequent decline of commercial activity resulting in many vacant properties. From the beginning of the 1990s, a variety of approaches to regenerate the typical downtown commercial districts have been seen. Previously, such initiatives focused only on the development of the physical environment of such districts, but in recent years a more coordinated approach involving measures to improve urban transportation, and guidance or restrictions on land use have come to the fore. Even in the 21st century era of online shopping, commercial districts should be restored as thriving places of hustle and bustle, where people come into actual contact with merchandise, experience services, and explore something new.

Under such circumstances, in 1998 three acts on city planning and development were passed with the aim of strengthening and supporting a revitalization policy for city centers, followed by further legislation in 2006 to amend the original three acts. However, the hollowing out of cities has not been stopped and no solution to the problem has been found yet; in an amendment of the Act on Special Measures Concerning Urban Reconstruction in 2014, under a plan for stream-lining locations, it was decided to promote the downsizing of urban communities. Against this background, the methodology to restore the former hustle and bustle of urban commercial centers still needs to be examined. Regeneration of ‘downtown’ in Central Business District has become an important policy, especially common in advanced countries. Even in the online shopping era of the 21st century, downtown should work as the ‘place’ where citizen visit and examine their preferred goods really in touch, try to experience novel services or look for discover something new beyond their daily life. Thus, downtown is needed in each metropolitan area.

Using DDyn, a prototype version of the Downtown Dynamics Model newly developed by the authors, the research conducted simulations for the sustainability of downtown commercial districts and analyzed the results. In addition, by com-paring with the four conditions for city diversity formerly advocated by Jane Jacobs (1961), the research examined the implications of the DDyn simulations.

2. Outline of the Downtown Dynamics Model

2.1 Configuration of the Entire Simulator

DDyn (Fig.1), which was used to conduct simulation analysis in the research, is composed of two types of agents, customer agents and shop agents, and a metropolitan area map, within which all the agents interact. In this simulator, every day, each customer agent selects a district to visit and behaves in accordance with the errands generated (Fig.2).

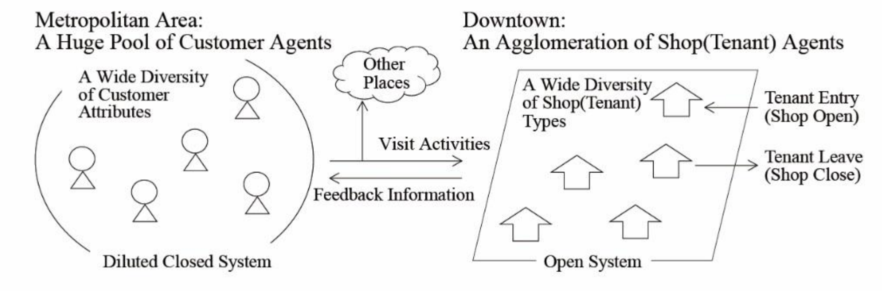

Fig. 1. System Components of Downtown Dynamics Model

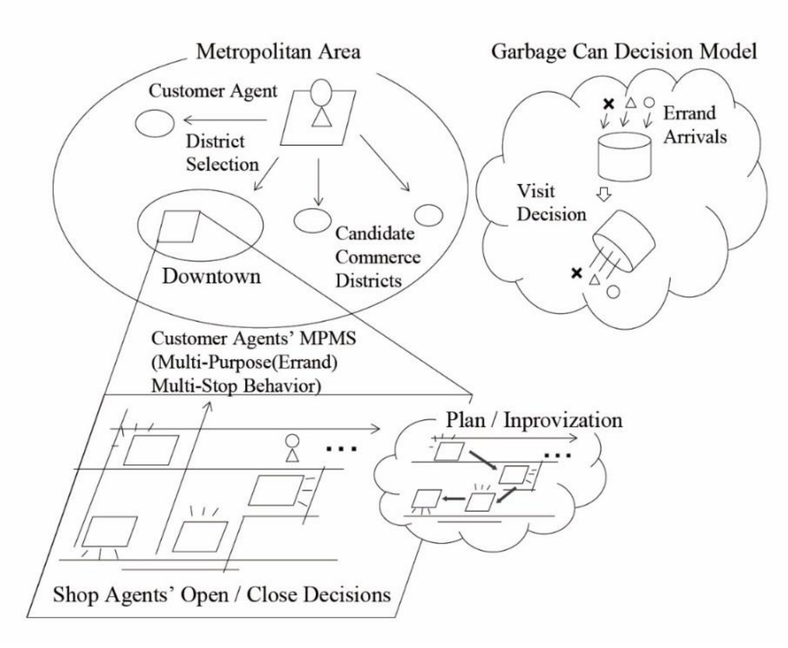

Fig. 2. Flow of DDyn Model in a Day

Ten weekend days/holidays are assumed as 1 month, and one time of simulation is conducted for a period of 2 years (240 days). As initial conditions, 6 types of customer agents with a total of 50 agents, 8 types of shop agents with a total of 72 shops are arranged on the metropolitan area map.

2.2 Configuration of Customer Agent

The algorithm of a customer agent (Fig.3) is described below. This algorithm is constructed based on simplified ASSA ver.2.0 (Kaneda, Yoshida(2012), Yoshida, Kaneda(2007, 2009, 2011, 2013a, 2013b)).

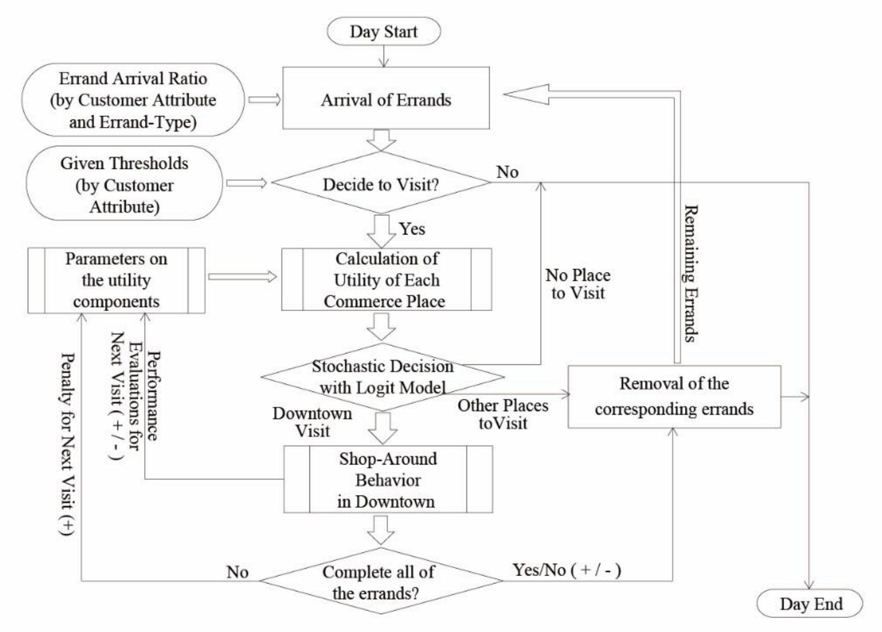

Fig. 3. Algorithm of Customer Agent

Firstly at the beginning of a day, errands for each customer agent are generated in accordance with the basic errand arrival ratio given for each customer stratum and errand type. When the type of the generated errand is equal to the set threshold or higher, the customer agent makes a decision on whether to visit or not (Garbage Can Decision Model). The threshold is fixed to 3 for all. After the agent has decided to make a visit, from parameters given to each of four commercial districts and the downtown, they calculate a utility value V for each district, and in accordance with a logit model, select a district to visit. When they decide to visit the downtown, they select a shop with the highest shop utility coefficient λ for each errand type, and based on the shortest route principle, draw up a route plan. At that time, the entrance and exit nodes are in accordance with the visiting means of transport of each customer agent. The customer agent upon entering a shop assesses the success or failure of an errand according to random numbers and by assuming an errand achievement probability of p = 0.6. When the agent fails to fulfill the errand, by breadth-first search they find a shop of the same errand type from a neighboring link, and setting this result as an alternative shop, create a route plan again, and start to walk. Moreover, as an impulse shop-around behavior, at a shop node the agent visits such a shop according to an impulse shop-around probability of r = 0.03. These shop visits affect the metropolitan area utility value V and shop utility coefficient λ at the next time.

2.3 Configuration of Shop Agent

The algorithm of a shop agent (Fig.4) is described below.

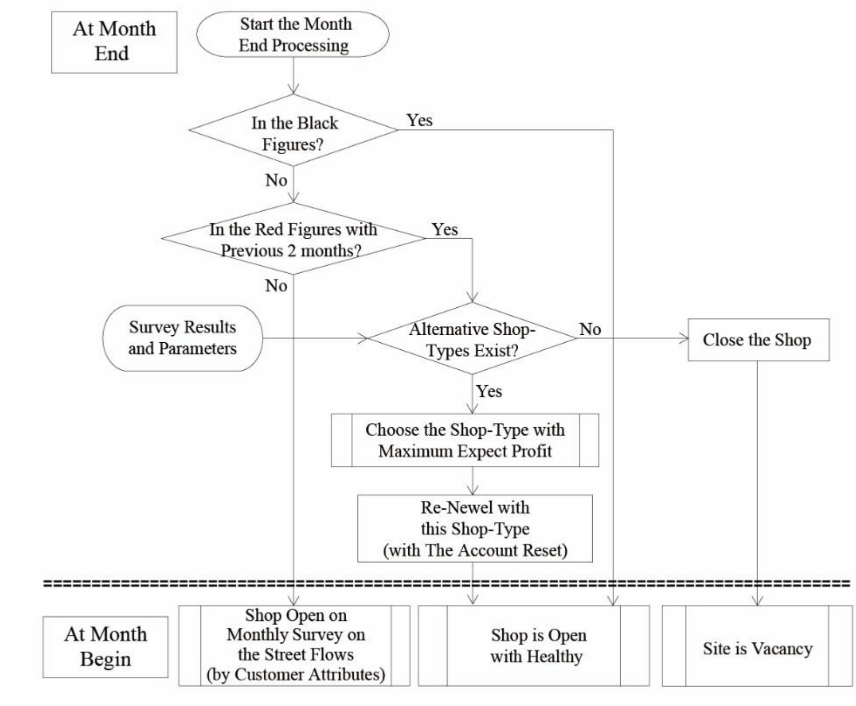

Fig. 4. Algorithm of Shop Agent

Each shop agent assesses monthly profit and loss based on the parameters (gross sales profit, fixed costs, and rent for the shop) given for each shop type at the end of every month. If a shop has a deficit for 2 consecutive months, the shop is closed. In the month following the two-month deficit, the number of customers who passed through the node of the closed shop is recorded, and an expected sales figure is calculated for each shop type. When the shop type with the highest figure is in the black, that shop type will open a new shop at the beginning of the following month. If no shop is in the black, the shop node will be empty and registered as a vacant shop.

2.4 Configuration of the Metropolitan Area Map

A metropolitan area map is made up of nodes indicated by a square, and adjacent nodes are connected by a link. A metropolitan area map is based on Osu district, Nagoya, Japan (Kobayashi et al. 2015; Takeuchi et al. 2011; Oiwa et al. 2005). On the nodes, a customer agent shown by a circle makes a move. The SOS (Shop On the Street) representation, where a shop is located on a node, was used. As the metropolitan area map, two maps including 72 shop nodes were prepared (Fig. 5, Fig. 6). To prevent any condition other than the city block scale from having an influence, the two maps were standardized with 72 shop nodes, 16 road nodes, and 4 entrance and exit nodes. In addition, 6 types of customer agents and 8 types of shop agents were prepared.

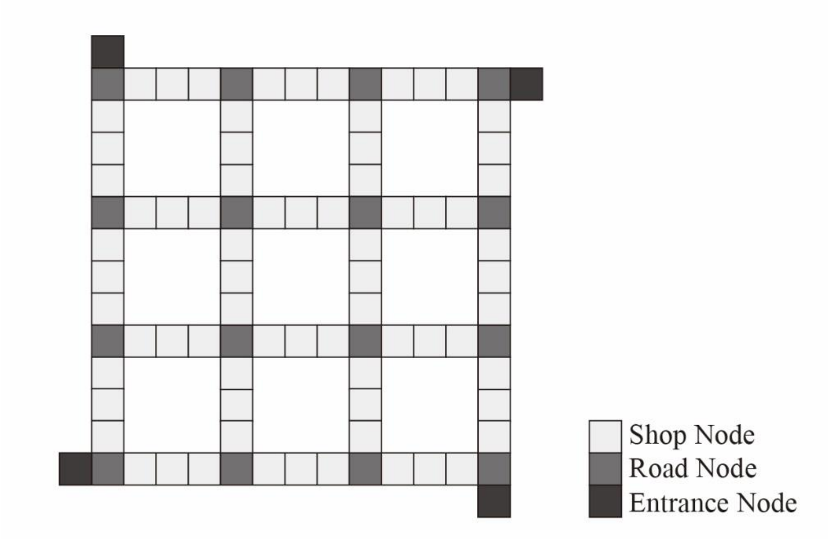

Fig. 5. Map of Small Block Size

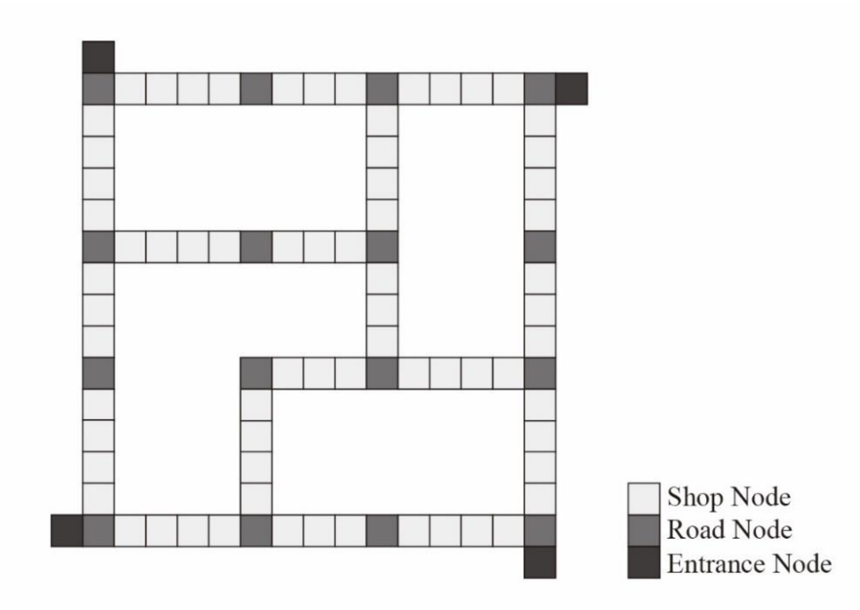

Fig. 6. Map of Large Block Size

3. Simulation Analysis of Sustainability of the Downtown Commercial District

3.1 Outline of Simulation

As described below, 6 cases with several different conditions were prepared, and simulation was conducted 20 times for each case, followed by analysis of the average values. One time of simulation was conducted for 240 weekdays/holidays. The following four types of data were analyzed: 1) the number of customers per month; 2) the number of shops per month; 3) Customer City Diversity Index (CCDI: Indicator of the Diversity of Customer Type Visited the Center City, see Eq. 3.1.1); and 4) Shop City Diversity Index (SCDI: Indicator of the Diversity of the Shop Type Opened, see Eq. 3.1.2).

$$entroC = (-1) \cdot \Sigma_{i \in CustomerTypeSet}(n_i/N) \cdot log_2(n_i/N) \quad (3.1.1)$$

$$entroS = (-1) \cdot \Sigma_{i \in ShopTypeSet}(n_i/N) \cdot log_2(n_i/N) \quad (3.1.2)$$

Case 0000: A small-scale city block map was set as the basic case. The initial shop type configuration of the 72 shops is as follows: 11, 11, 11, 8, 8, 8, 8, and 7. Agent's transport means are automobiles (30%) and public transport (70%).

Case 1000: The number of shops in Case 0000 was changed, and simulations conducted for a case with deviations in the number of shops allocated to each shop type: 36, 18, 9, 5, 3, 1, 0, and 0. All parameters other than the number of shops are the same as in Case 0000.

Case 0100: The map was changed to conduct simulations with a large-scale city block map as mentioned above. All parameters other than the map are the same as in Case 0000.

Case 0010: The shop rent parameter of Case 0000 was changed. The rent, 15 (14/72), 20 (14/72), 25 (16/72), 30 (14/72), or 35 (14/72) was allocated to the 72 shop nodes to conduct simulations for a range of rents, which were randomly allocated to the shop nodes. Parameters were set so that the average value of the rents is 25, which is the rent in Case 0000. All parameters other than the rent are the same as in Case 0000.

Case 0001: In the small-scale city block map, downtown residents were set as 40% of the customer agents to conduct simulations for a case that promotes living in the downtown district. Consequently, the means of transport were set as follows: automobile 18%, public transport 42%, and walking 40%. The downtown residents were positioned on the shop nodes at random. The time distance up to the metropolitan area map was significantly reduced (from 45 minutes to 5 minutes).

Case 0101: For the large-scale city block map as well, similarly to Case 0001, simulations were conducted for a case that promotes living in the downtown district.

3.2 Condition 1: Simulation analysis on the necessity of different primary uses

Case 0000 and Case 1000, where the number of shops was changed for each shop type, were compared, and the results are shown in Fig. 7 and described as below:

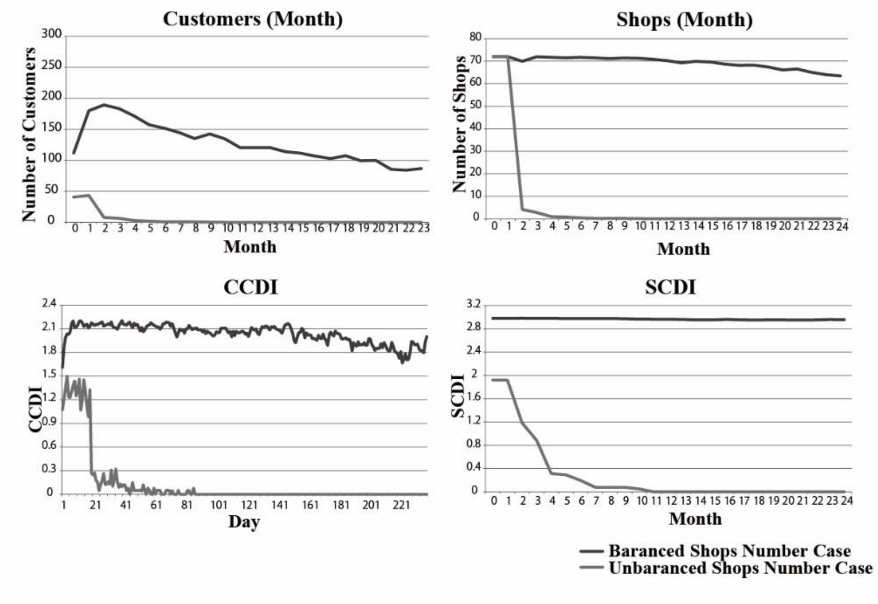

Fig. 7. Results of Simulation in the Different Primary Use Cases

In Case 0000, in which deviations were given to the number of shops in each shop type, both the numbers of customers and shops declined at an early stage. This is because the deviations caused a loss of diversity from the early stage, which is also clearly shown by CCDI and SCDI.

3.3 Condition 2: Simulation analysis on the necessity of small city blocks

Case 0000 and Case 0100, in which the city block scales differ, were compared, and the results are shown in Fig. 8 and described as below:

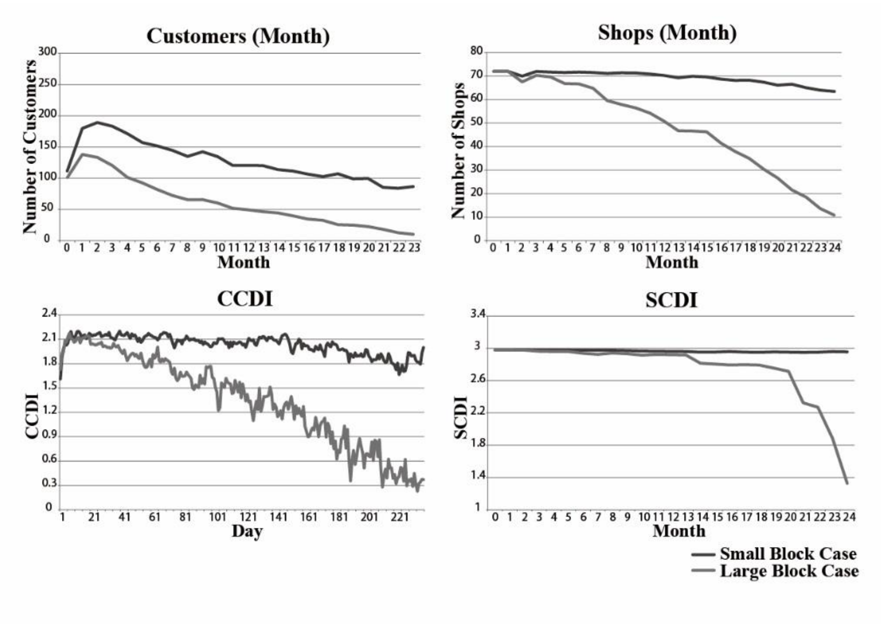

Fig. 8. Results of Simulation in Different Block Size Cases

When the numbers of customers were examined, in both cases, Case 0000 with a small city block scale and Case 0100 with a large city block scale, the numbers tended to decrease; however, Case 0000 always showed a higher number. Concerning the number of shops, there was a sudden decrease in Case 0100, whereas in the small block scale the number hardly decreased, and a significant difference was seen at the end of the simulation. In CCDI and SCDI as well, this tendency was also noticeable. This means that in Case 0100 specific types of customers and shops decreased, causing disparities among them, but in Case 0000 they decreased evenly with no disparity; therefore, it can be said that Case 0000 maintained more diversity.

3.4 Condition 3: Simulation analysis on the necessity of old buildings

Case 0000 was compared with Case 0010, where different rents were set, and the results are shown in Fig. 9, and described as below:

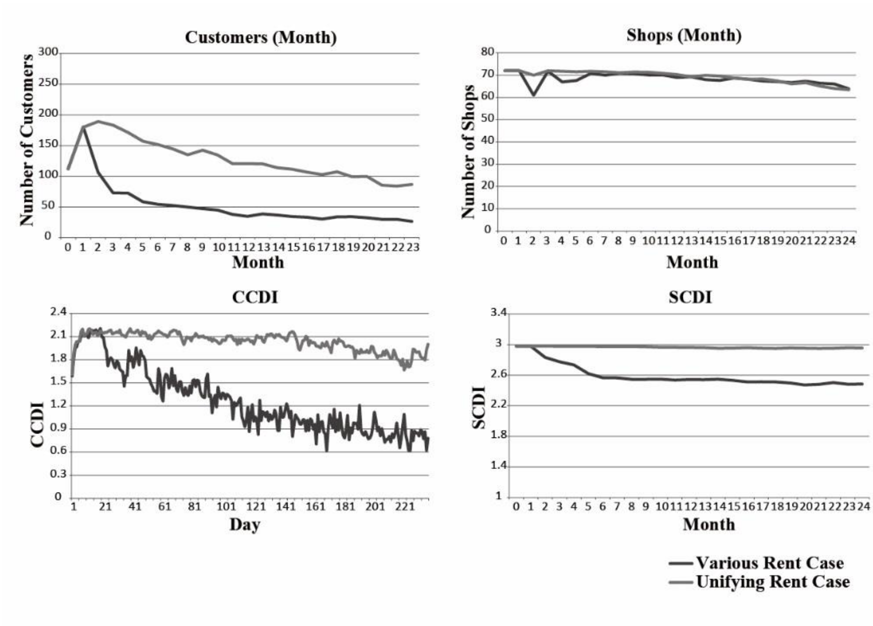

Fig. 9. Results of Simulation in Cases with Different Building Age Cases

Virtually no difference was found in the number of shops; however in SCDI, the values of Case 0010 with different rents significantly declined, generating a deviation in the shop type. Moreover, in the number of customers CCDI, the Case 0010 values were lower; these results are different from the condition as presented by Jane Jacobs. This could be the results of an inconsistency in the combination of a break-even point set for each shop and the given rent, due to random setting of the rents to the shop nodes; this point is an ongoing analysis task that needs to be monitored. However, the simulation results do support Jacobs' assertion that if diversity is lost, a city center will fall into decline.

In addition, the interpretation of representing old and new buildings by setting different shop rents as a case condition also requires reexamination. If Condition 3 becomes effective only after the "local characteristics" of old townscapes are incorporated in the case conditions of simulations, such knowledge as well must be regarded as knowledge obtained through simulations undertaken with a constructive approach.

3.5 Condition 4: Simulation analysis on the necessity of density

In the small-scale city block map, Case 0000 and Case 0001 with their different residential densities were compared, and the results are shown in Fig. 10 and described as below:

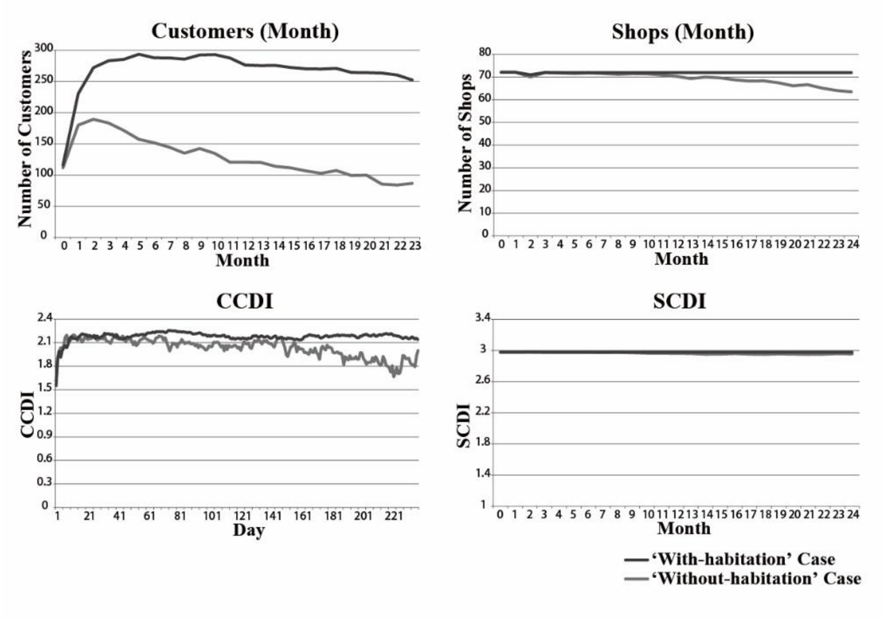

Fig. 10. Results of Simulation in Different Density Cases (Small Block Map)

When the numbers of customers were examined, a great difference was found between Case 0000 and Case 0001 with its downtown residents. Moreover, any decrease in the number of customers was reduced; the reason could be that the downtown residents visit the downtown district as regular customers. However, very little difference was found in the number of shops, CCDI, and SCDI.

In the large-scale city block map, Case 0100 and Case 0101, with their different residential densities, were compared and the results are shown in Fig.11.

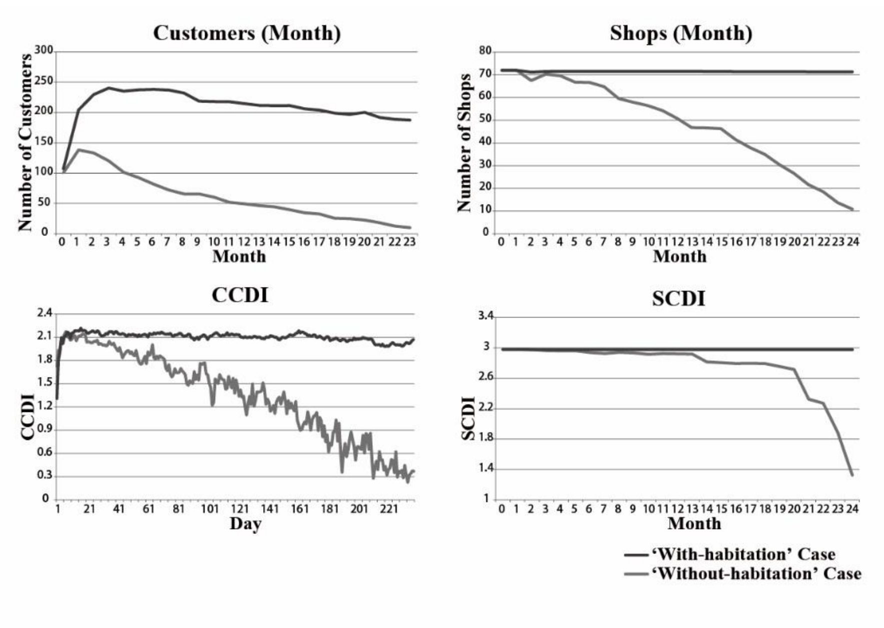

Fig. 11. Results of Simulation in Different Density Cases (Large Block Map)

Case 0101, where downtown residents were set, had values far above Case 0100 in both the number of customers and number of shops, resulting in the prevention of city center decline caused by a large block scale as indicated in Condition 2. Concerning CCDI and SCDI as well, the values of Case 0101 were also significantly higher; therefore, it can be said that diversity can more readily be maintained by encouraging a higher density and concentration of downtown residents. In the case of the large-scale city block map too, it was found that the decrease in the number of customers was reduced.

4. Conclusion

Using DDyn, a prototype version of the Downtown Dynamics Model, the research conducted simulation analysis for the sustainability of downtown commercial districts, and examined four conditions to form city diversity as presented by Jane Jacobs. The following describes the results obtained.

As the first simulation analysis, simulations were conducted and compared for cases with some degree of balance in the number of shops in each shop type, and with an unbalanced number of shops in each shop type. The results confirmed the case with a balanced number of shops maintained more city diversity, and contributed to the sustainability of a downtown commercial district. This result supports the necessity of mixed primary uses, which is Condition 1 of the four conditions for city diversity.

As the second simulation analysis, simulations were conducted and compared for cases with a small-scale city block map and a large-scale city block map. The results confirmed the case with the small-scale city block map maintained more city diversity, and contributed to the sustainability of a downtown commercial district. This result supports the necessity of small blocks, which is Condition 2.

As the third simulation analysis, simulations were conducted and compared for cases with a fixed rent and with different rents. As a result, the case with a fixed rent had an advantage, and the simulation analysis in the research was unable to obtain results that support Condition 3.

As the fourth simulation analysis, simulations were conducted and compared for cases with and without downtown residents in each of the small-scale block and large-scale block maps. As a result, no large difference was found in the small-scale city block map, but in the large-scale city block map, it was confirmed that the case with downtown residents maintained more city diversity, and contributed to the sustainability of a downtown commercial district. This result supports the necessity of density, which is Condition 4.

As described above, from among the four conditions for city diversity advocated by Jane Jacobs, the research successfully conducted simulation analysis to validate Conditions 1, 2, and 4.

A task is left concerning the design of a simulation model that represents Condition 3, involving old and new buildings, by setting differences in the shop rents. If Condition 3 becomes effective only after the “local characteristics” of old townscapes are incorporated in the case conditions of simulations, such knowledge as well can be regarded as knowledge obtained through simulations undertaken with a constructive approach. It is a future task to clarify this aspect through simulation analysis taking into account “local characteristics.”

Acknowledgments

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