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Analysis on the Central Business District Decline in Uto City Based on the Gravity-Accessibility Measure

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ABSTRACT

A previous study of the central business district of Uto City, Kumamoto, Japan indicated that its decline was related to the operation of two newly built large-scale stores.This paper deals with the change in the number of customers by opening large-scale stores and surrounding traffic situation based on Gravity - Accessibility measure.

Keywords: *Gravity -Accessibility measure, central business district, decline, customer*

INTRODUCTION

Uto is a city located in Kumamoto Prefecture, Japan. As of May 2014, thetotal population is 38,010 including 18,238 men and 19,772 women in the total area of 74.17 km2. However, the population living in Uto City central business district with a total area of 250 ha, as of March 2000, is 7,048 including 3,349 men and 3,699 women. According to the census of May 2014, the number of male and female population living in the business central district is 5,257 and 5,878, respectively, in the total population of 11,257. Male population increased 1.57 times, while female population increased 1.59 times as many as in 2000. Population density had reached 44.5 people/ha. It could be said that the population of the city central district had remarkably grown in compared with that of the entire Uto city[1].

In 1987, the first large-scale retail store with the area of 2,656 m2 was opened in the North West of Uto city central area, while the second one with 42,321 m2 area in the South East was first launched 8 years later. Due to the operation of two newly built large-scale stores, the center of central shopping area is no longer located in the shopping street of the city [2] but instead has shifted to the side of one of these stores at the southeast of the city.

The decline factor of the central shopping area is also related to moving distance, store size, number of items, shopper's preferences, etc. This paper deals with the change in the number of customers by opening large-scale stores and surrounding traffic situation based on Gravity - Accessibility measure.

CHANGES IN THE NUMBER OF CUSTOMERS DUE TO THE OPENING OF LARGE-SCALE STORES

In this study, the accessibility is based on the gravity model defined by following equation according to Walter G. Hansen. The relative measure of accessibility to activities located within zone Y in zone X showed in Figure 1 is defined as follows.

$$A_Y^X = \frac{S_Y}{T_{X-Y}^2} \quad (1)$$

where

A_Y^X : relative measure of the accessibility in zone X of an activity in zone Y

S_Y :the size of the activity in zone 2

T_{X-Y}: the distance of separation between zone 1 and zone 2.

In our calculation, zone X is 10 residential areas with Ⓐ toⒿ as showed in Table 1. Zone Y is a Block① to a Block⑦ in the central shopping mall shown in Figure 2. The area number surrounded by circles in the figure is the center position of the area. Similarly, the Block number surrounded by circles in the figure is the center

position of the Block.

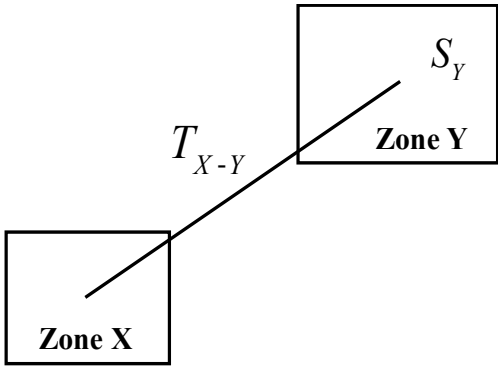

Figure1.*the concept of accessibility measures*

Table 2 indicates the linear distance between each area and Block. The shortest distance is 55 meters between ⑦ and Ⓙ, the longest distance is 1725 meters between ⑦ and Ⓑ. In addition, as showed in Table 2, the largest population is 2351 people inⒾ, followed by 2148 people in Ⓑ, 2043 people in Ⓒ, 2024 people in Ⓐ, respectively.

Next, Figure 3 shows the floor area of all shops in each Block. The floor areas of Blocks ① to ⑦ are 1312 m^2, 1290 m^2, 1848 m^2, 2430 m^2, 1778 m^2, 2790 m^2, and 2185m^2, respectively.

By substituting the above data into equation (1) and calculating accessibility, the results in Table 3 are obtained. A table element shown in yellow is when the accessibility value of the vertical Block number and the horizontal area is the largest, that is, the resident of the area is easier to reach the Block than other Blocks. Therefore, as the frequency of shopping gradually increases, it becomes a customer.

The result is shown in Figure 4. It can be estimated that 4172 residents from areas Ⓐ and Ⓑ will become customers in Block ①.

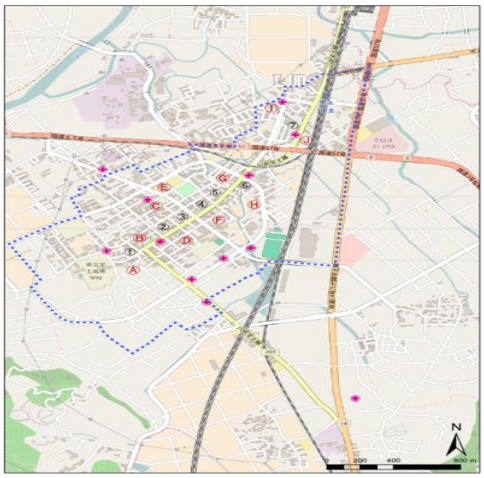

Figure2.*Locations of residential area and Block*

Table1.*Residential area in Uto city*

Area	town	population
Ⓐ	Ichiriki machi	103
	Ichiriki Nishi	80
	Irichi machi	317
	Goryohashi	307
	Irichi danchi	420
	Irichi New town	552
	Irichi chyuo	245
	Sum	2024
Ⓑ	Shinmachi 1 cho	251
	Shinmachi 2 cho	67
	Jyofu machi	139
	Honmachi 1 cho	130
	Monuchi	270
	Minamidanbara	454
	Kojyo machi	468
	Shinmachi danchi	239
	CareUto	43
	Ichibankan	87
	Sum	2148
Ⓒ	Takayana	1110
	Sakaemachi	694
	Uratamachi	114
	Shinmachi 4 cho	64
	Honmachi 3 cho	61
	Sum	2043
Ⓓ	Shinmachi 3 cho	67
	Honmachi 2 cho	73
	Shinkoen	64
	Shokoen	23
	Sum	227
Ⓔ	Kitadanbara	664
	Sum	664
Ⓕ	Honmachi 4 cho	64
	Shinkoji machi	201
	Sum	265
Ⓖ	Honmachi 6 cho	79
	Ishikoji machi	125
	Funaba machi	92
	Sum	296
Ⓗ	Honmachi 5 cho	50
	Ayaori	100
	Asahi danchi	88
	Sum	238
Ⓘ	Tuigome machi 1	601
	Tuigome machi 2	74
	Shinmatsubara	794
	Ohira danchi	177
	Matsubara danchi	125
	Fukurouchi	171
	Sajiccho machi	409
	Sum	2351
Ⓙ	ShinMatsubara	214
	Ebe	392
	Jyonoura 1	317
	Jyonoura 2	153
	Ekimae danchi	155
	Sum	1231

Similarly, 2270 residents fromareas Ⓒ and Ⓓ, 909 residents fromareas Ⓔ and Ⓕ, Ⓕ, 534 residents fromareas Ⓖ and Ⓗ, 3582 residents fromareas Ⓘ and Ⓙ will become customer in Block③,④, ⑤, ⑥and ⑦, respectively.

Table2.*Linear distance between areas and Blocks*

Erea		Distance to Block(m)						
Symbol	population	①	②	③	④	⑤	⑥	⑦
Ⓐ	2024	100	262.5	512.5	700	800	962.5	1625
Ⓑ	2148	100	132.5	400	587.5	680	825	1725
Ⓒ	2043	437.5	325	212.5	312.5	380	512.5	1125
Ⓓ	227	337.5	225	145	305	407.5	560	1250
Ⓔ	644	775	680	562.5	562.5	557.5	607.5	975
Ⓕ	265	557.5	437.5	150	100	212.5	355	1025
Ⓖ	296	805	695	392.5	212.5	112.5	62.5	725
Ⓗ	238	845	725	450	295	262.5	257.5	812.5
Ⓘ	2351	1487.5	1375	1087.5	912.5	812.5	700	87.5
Ⓙ	1231	1362.5	1232.5	937.5	750	655	505	55

Table3.*Accessibility measure*

Erea		Block number						
Symbol	population	①	②	③	④	⑤	⑥	⑦
Ⓐ	2024	131.2	18.7	7.0	5.0	2.8	3.0	0.8
Ⓑ	2148	131.2	73.5	11.6	7.0	3.8	4.1	0.7
Ⓒ	2043	6.9	12.2	40.9	24.9	12.3	10.6	1.7
Ⓓ	227	11.5	25.5	87.9	26.1	10.7	8.9	1.4
Ⓔ	644	2.2	2.8	5.8	7.7	5.7	7.6	2.3
Ⓕ	265	4.2	6.7	82.1	243.0	39.4	22.1	2.1
Ⓖ	296	2.0	2.7	12.0	53.8	140.5	714.2	4.2
Ⓗ	238	1.8	2.5	9.1	27.9	25.8	42.1	3.3
Ⓘ	2351	0.6	0.7	1.6	2.9	2.7	5.7	285.4
Ⓙ	1231	0.7	0.8	2.1	4.3	4.1	10.9	722.3
floor space		1312	1290	1848	2430	1778	2790	2185

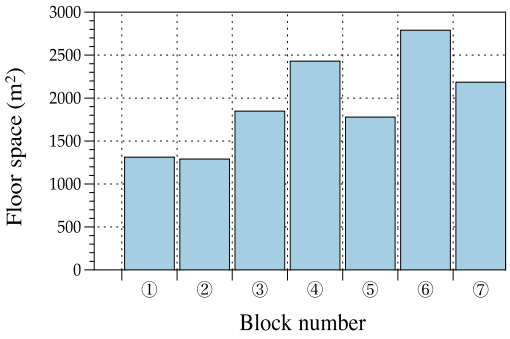

Figure3.*Floor space of total store in each Block*

The above is equal to the number of customers before the opening of both large-sized stores. Let us consider how the number of clients after opening large-sized stores changes.

First, Figure5 shows the location of both large-sized stores. In the figure, we illustrate the shopping center Pear by P-shop and Uto City Mall with U-shop, respectively. P-shop is approaching areas Ⓒ and Ⓔ while U-shop as far apart from each area. Table 4 shows in the straight-line distance between both of large-scale stores and each area.

Table4. *Linear distance between areas and two large-scale store*

Erea		Distance to LSS(m)	
Symbol	population	U-shop	P-shop
Ⓐ	2024	41	33.5
Ⓑ	2148	44.3	23.3
Ⓒ	2043	39.8	11.2
Ⓓ	227	30.5	24
Ⓔ	644	50.5	4.2
Ⓕ	265	26.3	22.8
Ⓖ	296	31	21
Ⓗ	238	19	31
Ⓘ	2351	52	40
Ⓙ	1231	37	39.5

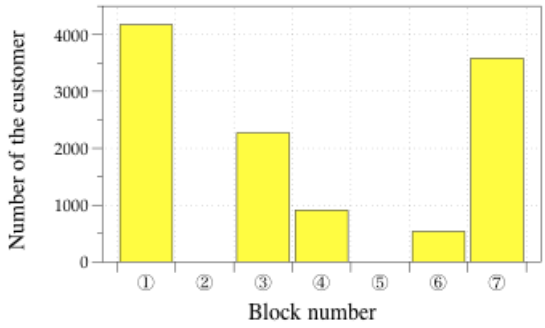

Figure4. *Estimated customers in each Block*

By substituting the straight distance in Table 4 and the floor area of both large-scale stores into the equation (1), the accessibility value is obtained as showed in Table 5.

As a result, as shown in the green bar chart of Figure.6, It can be estimated that 4172 residents from areas Ⓐ and Ⓑ will become customers in Block①. Similarly, 227 residents fromareas Ⓓ, 265 residents from area Ⓕ, 296 residents from area Ⓖ, 3582 residents fromareas Ⓘ and Ⓙ will become customer in Block③,④,⑤,⑥and⑦, respectively. On the other hand, 238 people in U-shop and 2687 customers in P-shop will win customers. The yellow bar graph in Figure 6 represents the number of customers before the opening of both large-sized stores.

Finally, let us considering the change in thenumber of customers before and after opening both of large-scale stores. In Figure 6, the number of customers in Block①and Block⑦does not change but the number of customers in Blocks ③, ④ and ⑥ is decreasing. First, in Block③, there were 2270 residents in areaⒸandⒹ, but after the opening of both large-scale stores, 2043 residents in Ⓒ area change to P-shop, and as a result, only 227 residents in area Ⓓ are customers.

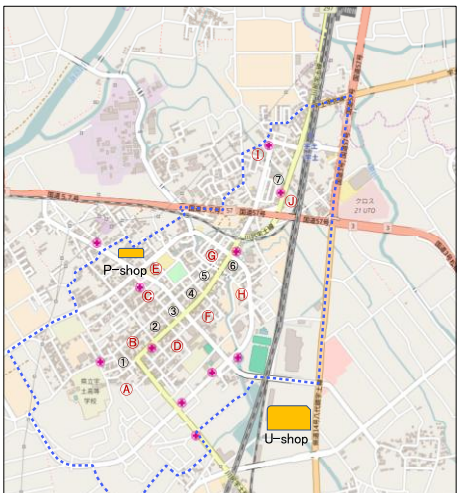

Figure5.*Location of two large-scale stores*

Table5.*Accessibility measure after opening of large-scale shops*

Erea		Block number							Large scale S	
Symbol	population	①	②	③	④	⑤	⑥	⑦	U-shop	P-shop
Ⓐ	2024	131.2	18.7	7.0	5.0	2.8	3.0	0.8	39.3	8.1
Ⓑ	2148	131.2	73.5	11.6	7.0	3.8	4.1	0.7	33.7	16.7
Ⓒ	2043	6.9	12.2	40.9	24.9	12.3	10.6	1.7	41.7	72.1
Ⓓ	227	11.5	25.5	87.9	26.1	10.7	8.9	1.4	71.1	15.7
Ⓔ	644	2.2	2.8	5.8	7.7	5.7	7.6	2.3	25.9	513.0
Ⓕ	265	4.2	6.7	82.1	243.0	39.4	22.1	2.1	95.6	17.4
Ⓖ	296	2.0	2.7	12.0	53.8	140.5	714.2	4.2	68.8	20.5
Ⓗ	238	1.8	2.5	9.1	27.9	25.8	42.1	3.3	183.1	9.4
Ⓘ	2351	0.6	0.7	1.6	2.9	2.7	5.7	285.4	24.5	5.7
Ⓙ	1231	0.7	0.8	2.1	4.3	4.1	10.9	722.3	48.3	5.8

Next, in Block 4, there were 909 residents in

area Ⓔ and Ⓕ, but after the opening of both large stores, 664 residents in area Ⓔ changed to the P-shop, and as a result, only 265 residents in area Ⓓ are customers. Finally, at Block⑥ there were 534 residents in area Ⓖ and Ⓗ, but after the opening of both large stores, 238 residents in area Ⓗ changed to the U-shop, and as a result, only 296 peoples in area Ⓖ are customers.

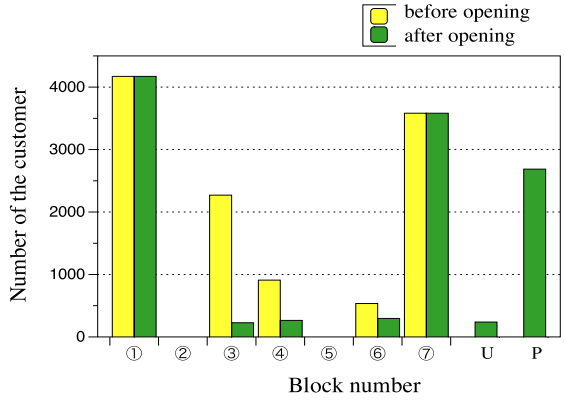

Figure6.*Changes in the number of customers before and after the opening of two large-scale retail stores*

CHANGES IN THE NUMBER OF CUSTOMERS DUE TO THE SURROUNDING TRAFFIC SITUATION

It is needless to say that the central city area of Uto City and the decline factor of the central shopping district are greatly related to the surrounding traffic situation. As showed in Figure 1, there are three main entry routes to the central city area and the central shopping district. Route R1 in the south, route R2 in the center and route R3 in the east. The approach routes R1 and R3 enter the Block① and Block⑦, respectively after passing through the Blocking type railroad crossing of JR Railway. On the other hand, the approach route R2 enters between the Block③and the Block④ after going through the elevated transportation route. Both approaching roads are the roads diverted from the prefectural road UTO KAGAMIYATSUSHIRO line, former Route 3.

By the way, in the year 1992, the eastbound new Route 3 line was opened. Being dependent on the statistics of the Ministry of Land Infrastructure Transport, the number of vehicles traveling on former Route 3 was 22,053 (vehicles/12h) however decreased to 17,831 (vehicles/12h). That is, the number of traffic vehicles of 4,222 (vehicles/12h) reduced. A decrease in the number of vehicles traveling at about 20% can be regarded as one factor that declines in the central shopping area.

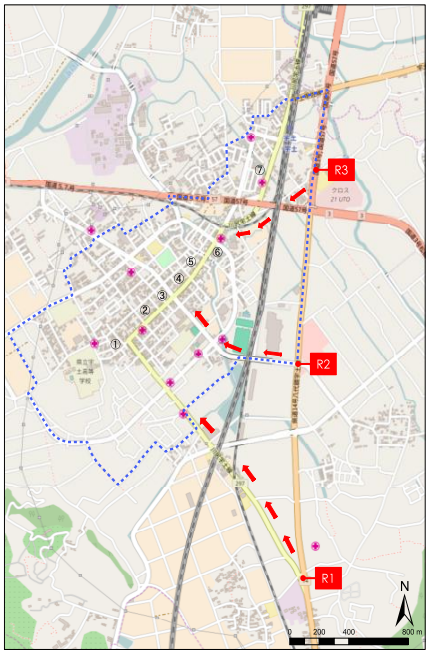

Figure7.*Changes in the number of customers before and after the opening of two large-scale retail stores*

In this section, we grasp the number of vehicles passing through the central shopping district before and after the opening of the new Route 3 using Gravity-Based Accessibility Measure and clarify the factor of decline in the central shopping district.

In this calculation, the zone X is the point of approach route R1, R2, R3 showed in Table 6, and the zone Y is the Block① to Block⑦ of the central shopping mall shown in Figure 7. The number of entering vehicles on each approach road was determined by measuring the average from 7:00 am to 18:00 pm in three successive days.

Table6.*Distance between R1,R2,R3 and Blocks*

Route	Number of entering vehicles (cars/12h)	distance to block (m)						
		①	②	③	④	⑤	⑥	⑦
R1	3683	1980	2190	2350	2540	2640	2790	3260
R2	8838	1373	1163	1003	1114	1214	1364	1834
R3	1914	2930	2720	2560	1370	1270	1120	730

First, substituting the data in Table 6 into equation (1) to calculate accessibility factor the results in Table 7 are obtained. It can be seen from Table 7 that the accessibility values for each approach route R1, R2, R3 are the largest in Blocks ①, ③ and ⑦. That is, it means that these Blocks are easier to reach than other Blocks, in other words, the frequency of shopping is considered to be abnormal.

Table7. *Accessibility measure*

Route	Number of entering vehicle[vehicles/12h]	Accessibility Measure						
		①	②	③	④	⑤	⑥	⑦
R1	3683	0.94	0.77	0.67	0.57	0.53	0.47	0.35
R2	8838	4.69	6.53	8.79	7.1	6	4.75	2.63
R3	1914	0.22	0.26	0.29	1.02	1.19	1.53	3.59

Therefore, if the Block having the largest accessibility value is replaced to the entry number of the approach route then Figure 8, Figure 9 and Figure 10 are obtained. Next, when we calculate the sum of them, the number of entering each Block from R1, R2, R3 becomes as shown in Figure 10.The largest number is 11,609[vehicles/12h] in Block③, 9,945 [vehicles/12h] in Block④, 9,722[vehicles/12h] in Block②, 8,737 [vehicles/12h] in Block⑤, 8,518[vehicles/12h] in Block①, 7,447 [vehicles/12h] in ⑥, and 5,916 [vehicles/12h] inBlock⑦, respectively.

The above is the number of entering vehicles after the new Route 3 is opened. Next we predict how the number of entering vehicles before opening will change.

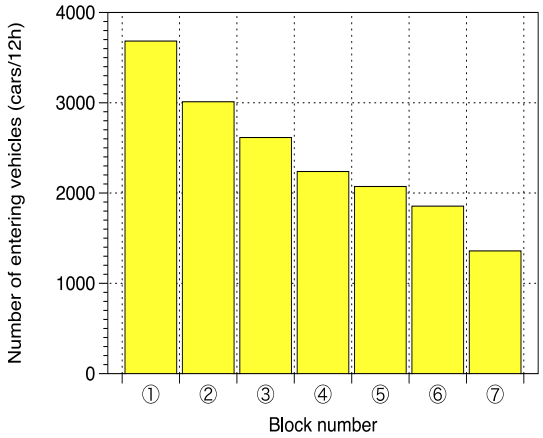

Figure8. *Number of entering vehicles from R1*

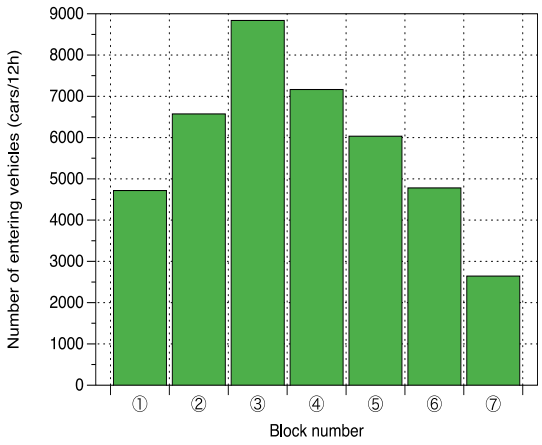

Figure9. *Number of entering vehicles from R2*

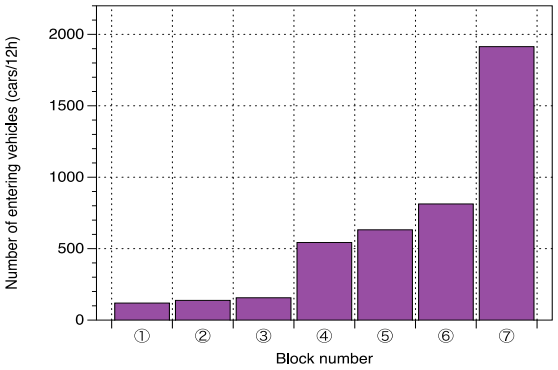

Figure10. *Number of entering vehicles from R3*

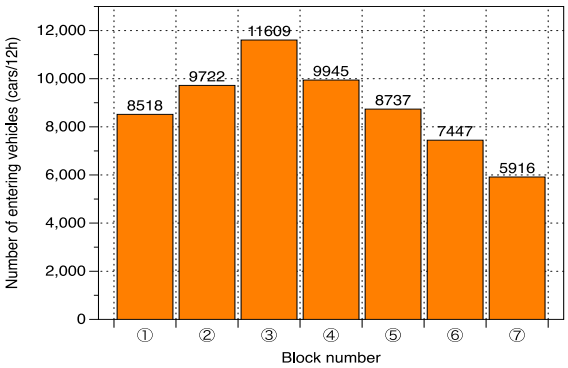

Figure11. *Number of entering vehicles for each Block after the opening of new Route 3*

As described above, in the year 1992, the eastbound new Route 3 was opened. Being dependent on the statistics of the Ministry of Land Infrastructure Transport, the number of vehicles traveling on former Route 3 was 22,053 (vehicles/12h) however decreased to 17,831 (vehicles/12h). That is, the number of traffic vehicles of 4,222 (vehicles/12h) reduced. A decrease in the number of vehicles traveling at about 20% can be regarded as one factor that declines in the central shopping area.

By multiplying the number of entrances of the approaching routes R1, R2 and R3 by 20%, the number of entrances of the approaching routes R1 increases from 3,683 to 4,420 (vehicles/12h). Similarly, R2 increases from 8,838 to 10,606 (vehicles/12h), R3 increases from 1,914 to 2,297 (vehicles/12h), respectively. By using these numbers and compute by the same procedure as above, the result is obtained as showed in Figure 12. The largest number is 13,931 in Block③ 11,936 in Block④, 11,666 in Block②, 10,485 in Block⑤, 10,223 in Block①, 8,937 in Block⑥, 7,099 in Block⑦ in order. Therefore, the change in the number of entrances before and after the opening of the new Route 3 line is obtained by the difference between Figure 11 and Figure 12 as showed in Figure 13. Since the

number of vehicles decreased is proportional to the number of shoppers, it is seen as a factor of declining the central shopping area.

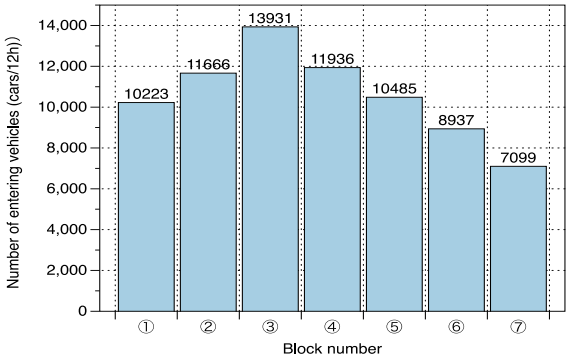

Figure12.*Number of entering vehicles for each Block before the opening of new Route 3*

CONCLUSION

The changes in the number of customers due to the opening of large-scale stores were analysis by using Gravity-Based-Accessibility measures. The gravity model concerns shoppers only with regard to the size of the store and the straight distance from the residence to the store without considering the attractiveness and preference of the store.

The following results were obtained in this study:

(1) Block① and Block⑦ are not affected by the opening of both large-scale shops, the number of customers before opening and after opening is unchanged.

(2) Because the areas Ⓒ and Ⓔ are quite close to the shopping center peers, the residents of both areas leave Blocks ③ and ④ and become customers of the shopping center peers.

(3) Residents of area Ⓗ leave Block⑥ and becomes a customer of U-shop.

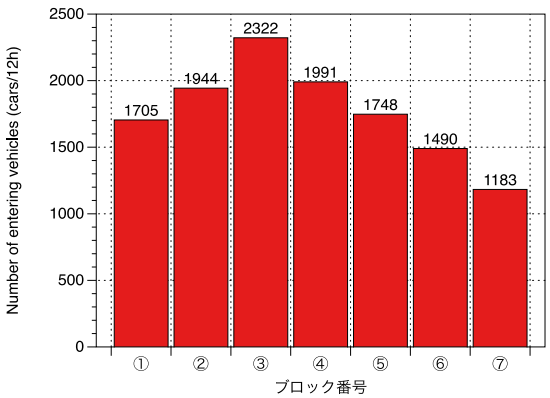

Figure13. *Changes in the number of entering vehicles before and after the opening of new Route 3.*

The decline factor in the central city area of Uto City and the central shopping district is greatly related to the traffic situation in the surroundings. In 1992, the eastbound new Route 3 was opened, so the traffic volume of the former Route 3 line decreased by 20%. As a result, the number of vehicles entering the central shopping district will decrease, which is seen as a decline factor in the central shopping district. To clarify this situation, in this study. We verify using the accessibility index of the gravity model based on measured traffic volume.

As a result, the decrease in the number of vehicles before and after the opening of the new Route 3 is 2,322[vehicles/12h] in Block③, 1,991[vehicles/12h] in Block④, 1,944 [vehicles/12h] in Block②, 1,748[vehicles/12h] in Block⑤, 1,705[vehicles/12h]in Block①, 1,490 [vehicles/12h] in Block ⑥ and1,183 [vehicles/12h] in Block ⑦, respectively. Since the number of vehicles reduced is proportional to the number of shoppers, it is considered as a factor of declining the central shopping area.

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