A Study on the Tour and Consumption Behavior at Station Areas in Considering the Green Coverage

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1 INTRODUCTION

1.1 Background

In recent years, seismic activity has intensified, emphasizing the need for resilient cities that can handle disasters. In this context, a "phase-free" environment, meeting both daily and emergency needs, is gaining attention. Green open spaces play a vital role in this approach, serving as daily recreational spaces and emergency resources. Japan's rapid urbanization during its economic boom led to reduced green spaces, but these are now valued for mitigating the urban heat island effect and enhancing resilience. The COVID-19 pandemic highlighted their benefits for health, quality of life and pedestrian activity. It is also reflected in the 2023 Third National Spatial Planning Act, which promotes urban vibrancy and disaster mitigation of green spaces. Moreover, the Sixth Tokyo Metropolitan Area Person Trip (PT) survey (Tokyo Metropolitan Area Transportation Planning Council, 2018) introduced expenditure data, linking travel behavior with consumption.

1.2 Purpose

This study hypothesizes that green open spaces, such as urban parks and street trees, stimulate travel and local spending, enhancing urban vitality in daily context. Using expenditure data from the PT survey, it develops a model explaining consumption based on personal and regional characteristics. Quantifying these effects can inform policies that support a phase-free environment.

1.3 Literature Review

Kimura et al. (2018) found that Minami Ikebukuro Park visitors walked more and suggested public spaces encourage people to travel more. In Kyobashi, pedestrians preferred green routes over shorter paths when going to parks for comfort and safety (Takatori & Ishikawa, 2010). Also, green spaces raise real estate value (Yazawa & Kanemoto, 1992). Green spaces create attractive spaces and potentially increase the consumptions nearby; therefore, this study focuses on the green coverage observed from above, including the greenery along sidewalks. Kondo et al. (2017) noted that consumption rises with group activities and late-hour travel in business scene, using Tobit model. Yoshimura et al. (2022) showed that pedestrian-friendly environments enhance consumption.

1.4 Positioning of This Research

This study explores relationship between Tokyo's green open spaces and consumption via travel behavior which leads to urban vibrancy. This research is novel in two respects: (a) it utilizes newly collected consumption data from PT survey to capture the relationship between greenery, trip behavior, and consumption behavior in a large scale, and (b) formulates consumption behavior in everyday contexts. Through methods of extracting greenery from the green coverage map, comparing trips and consumption between individuals exposed to greenery and those who are not, utilizing Tobit model to investigate how much green coverage contributes to consumption behavior. It further analyzes area-specific characteristics to capture regional differences.

2 Study Area and Data

2.1 Study Area

The study area is within Tokyo's JR Yamanote Line and 1.5 km buffer around it to analyze active travel and consumption behavior, as shown in Figure 1.

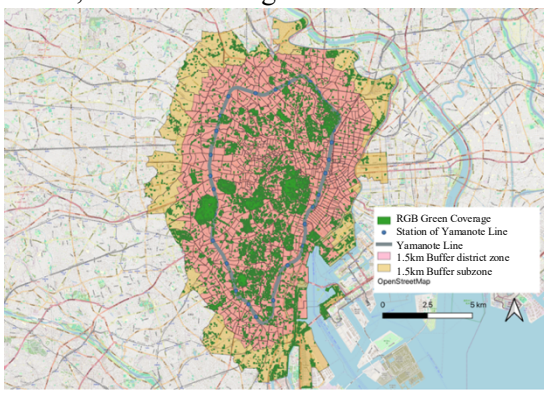

Figure 1 – *Study Area (1.5km Buffer of Yamanote Line)*

2.2 Data

Consumption data was obtained from the sixth Tokyo Metropolitan Area PT Survey, conducted from September to November 2018 on weekdays, capturing personal attributes and movement patterns. New items were added in 2018 survey, such as expenditure at destinations and geographic coordinates. Geographical data, including zoning, land use and real estate prices, was obtained from National Land Numerical Information (MLIT) and e-stat (Statistics Bureau of Japan). Various data layers, including daytime population density, number of stores, urban parks and green coverage were visualized in QGIS. The 2007 green coverage map (MLIT, 2007) was processed in Python using OpenCV to identify green areas (using RGB and HSV color spaces), later vectorized in QGIS. Each pixel in the final green coverage represents 5.7 m^2, including street trees and rooftop greenery, while restricted zones were excluded. Green coverage rates were calculated by subzone.

$$\text{Green Coverage Rate} = (\text{Green Area in Subzone} \,/\, \text{Subzone Area}) \times 100 \quad (1)$$

3 Results

3.1 Contrast Based on Contact with Greenery

Individuals exposed to greenery had a significantly higher total trip count per day, suggesting that greenery may enhance people to travel more (left side of Table 1). However, total daily consumption varied based on transportation mode (right side of Table 1). With all travel mode, individuals exposed to greenery spent more money, but for walking trips, those not exposed to greenery reported

higher spending. To further investigate how much greenery coverage affects consumption amounts, the next section formulates consumption amounts using a Tobit model.

Table 1 – *Contrast of Number of Trips and Consumption Based on Contact with Greenery*

	Total Number of Trip [trips]			Total Daily Consumption [yen]		
	All Mode	Walk		All Mode	Walk	
Green	3.76	2.52		4,169.00	1,942.26	
No Green	2.68	1.96		2,646.90	5,357.17	
	Statistic	Statistic	Result	Statistic	Statistic	Result
U Test	2.66E+11*	5.42E+10*	(Median) Significant Difference	1.89E+11*	2.04E+10*	(Median) Significant Difference
F Test	488,951*	285,384*	Not Equal Variance	30.34*	28.08*	Not Equal Variance
Welch's t Test	151.97*	108.46*	(Average) Significant Difference	14.15*	-35.61*	(Average) Significant Difference

*: all p-value < 2.2e-16

3.2 Analysis Based on Formulation of Consumption

Since consumption amounts are greater than or equal to zero and about 46% of respondents reported zero consumption, Tobit model was chosen to formulate. This model illustrates the binary choice of whether to consume and the amount consumed as a continuous variable within a single function.

3.2.1 Walking Trip Analysis

Evening trips, trips to areas with high daytime population density, after visiting parks, high land prices and store density show higher spending. Areas near large parks (>4.7 ha) show higher consumption, contributing to both urban vibrancy and daily life. Areas with green coverage of 10-15% on RGB and 10-15% or 25-30% on HSV positively influence spending (Figure 2). Thus, trips after visiting parks, to areas near large parks and areas with moderate greenery increase consumption.

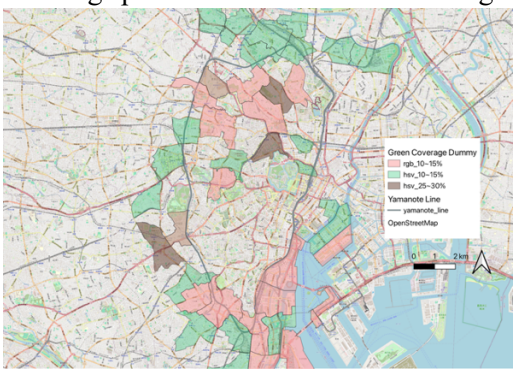

Figure 2 – *Green Coverage Rates Positively Influencing Consumption Amounts*

3.2.2 Tour Analysis

Using green coverage rates, either the maximum for each arrival area or as a log sum of all arrival points, reveals that higher greenery correlates with increased daily consumption. Green coverage over 0-5% consistently shows positive effects, with optimal impact at 30-35% for RGB and over 40% for HSV. Daily consumption also increases with age and more trips. Trips with 1-3 companions yield the highest consumption per tour, while solo or larger group trips show less spending per trip. The total number of trips within a tour exhibited a positive marginal effect, suggesting that a higher trip count correlates with greater consumption amounts.

3.2.3 Area Comparisons

1.5 km buffer around each station was analyzed for inter-area comparisons. Eight high-consumption areas and one low-consumption area were compared, revealing higher spending correlates with

purchasing both everyday goods and non-essential items purchases, longer stays, nighttime trips, and high daytime population density. Young consumers of 20s dominate in Harajuku and Shibuya, while those in their 80s are more prevalent in Ueno, 60s in Ikebukuro and 50s in other areas, though to be influenced by the target age demographics of the stores and the density of companies. Park visits positively impact consumption near five stations, while Shibuya, Tokyo, and Yurakucho are more affected by commercial factors. About the green coverage, although the degree of impact differed depending on the area, it was shown that the presence of greenery encouraged consumption in all areas. It was also noted that green coverage rates above 35% have a negative impact on consumption, likely due to fewer stores available in highly green areas.

4 Discussion

It has become evident that green open spaces enhance travel frequency and raise consumption nearby, through contrast of green exposure and Tobit model analysis in trip unit, tour unit and area specific.

Further analysis should refine this model by addressing the scarcity of negative consumption factors. Exploring whether parks extend stay time or if greenery directly influences spending could offer more insights. Moreover, examine whether increase in trips due to green open space results in a decrease in trips elsewhere or if it is potentially encouraging people to travel more and spend money. The PT survey effectively analyzes wide-area consumption behavior but is limited by weekday-only data collected every ten years. Integrating additional data could improve analytical precision and regional insights.

For future work, this research will continue to clarify that green open spaces contribute not only during emergencies but also during everyday life; moreover, examine optimal placements of green open spaces that facilitate evacuation in emergencies.

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