Identification and Analysis of Consumer Behaviors by Age and Gender within Commercial Facilities in the 23 wards of Tokyo from GPS Data

Luyao LIU, Jue Ma, Yoshihide Sekimoto

Background

With the accelerating social development and economic growth, the dynamics of consumer mobility and urban planning have grown increasingly intricate. A comprehensive understanding of consumer behavior within these complex urban settings is vital for optimizing commercial decision-making and guiding evidence-based urban planning. Recent advancements in technology and the proliferation of big data offer unprecedented opportunities for conducting fine-grained analyses of consumer behavior.

Methodology

The proposed approach consists of the following five major steps (Fig.1). (1) Cleaning of GPS data with missing values and calculation of a scaling coefficient based on the actual number of residents living in the 23 wards of Tokyo. (2) Identification of commercial facility boundaries, categorized as shopping centers and shopping streets, based on POI and building footprint datasets. (3) Mobility data mining, including stay point detection using various stay duration thresholds, and exclusion of workers based on commuting time and business hours in commercial areas (Fig. 2). (4) Comparison of GPS-based outputs with official visitor statistics reports. (5) Analysis of consumer behavior based on consumer preference ratios (Equation 1).

Fig. 1 Workflow of the proposed method

Fig. 2 Workflow of identification of consumer behavior

$$P_{\mathrm{GPS}}^{(g)} = \frac{N_{\mathrm{GPS}}^{(g)}}{N_{\mathrm{GPS}}}$$

$$P_{\mathrm{SC/SS}}^{(g)} = \frac{N_{\mathrm{SC/SS}}^{(g)}}{N_{\mathrm{SC/SS}}}$$

$$\mathrm{CPR}^{(g)} = \frac{P_{\mathrm{SC/SS}}^{(g)}}{P_{\mathrm{GPS}}^{(g)}}$$

Note:
N_{SCs}: the number of shopping centers
N_{SSs}: the number of shopping streets
N_{GPS}: the number of GPS users
$P^{(g)}$: proportion of group g
$\mathrm{CPR}^{(g)}$: consumer preference ratio of group g

Equation.1 Consumer preference ratio

Facility-specific consumer profiles

In Fig.3, GPS-based visitor numbers in the most of the commercial facilities closely approximate the actual visitor numbers when a 10-minute stay duration threshold is applied. In Fig.4, shopping centers attract markedly larger daily crowds than shopping streets on both weekdays and weekends. A typical center receives around 40000 visitors per day, whereas a shopping street averages roughly 20000. In Fig.5 and Fig.6: 1) Shopping centers thrive in the late-morning to early-evening, matching the business hours, whereas shopping streets pick up a late-night strolling crowd; 2) female bias is strong in both places; however, shopping centers gains more from afternoon-to-evening promotions, while shopping streets benefits from lunchtime events; 3) Seniors prefer shopping centers in the morning, like morning cafe and prefer shopping streets at night, like resting spots; 4) Youth prefer going shopping after school.
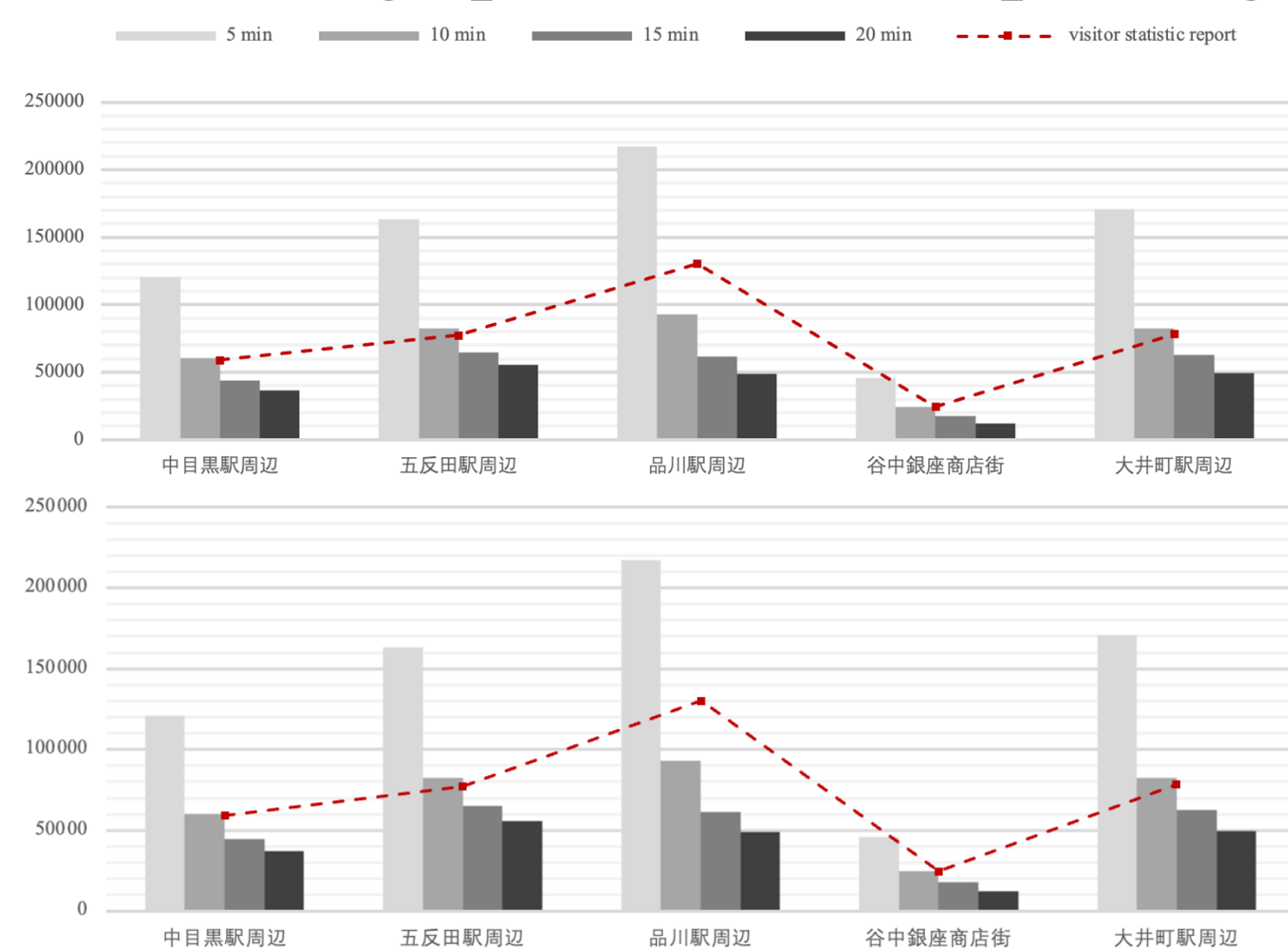

Fig. 3 GPS-based outputs vs. visitor statistic report under different stay duration thresholds (above: shopping centers, below: shopping streets)
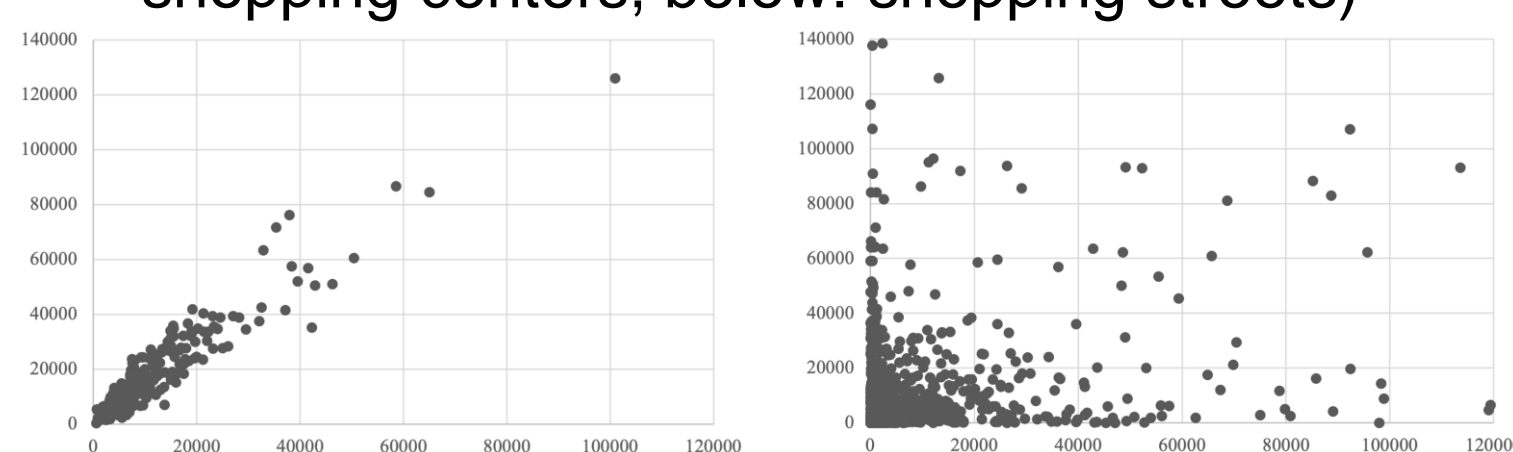

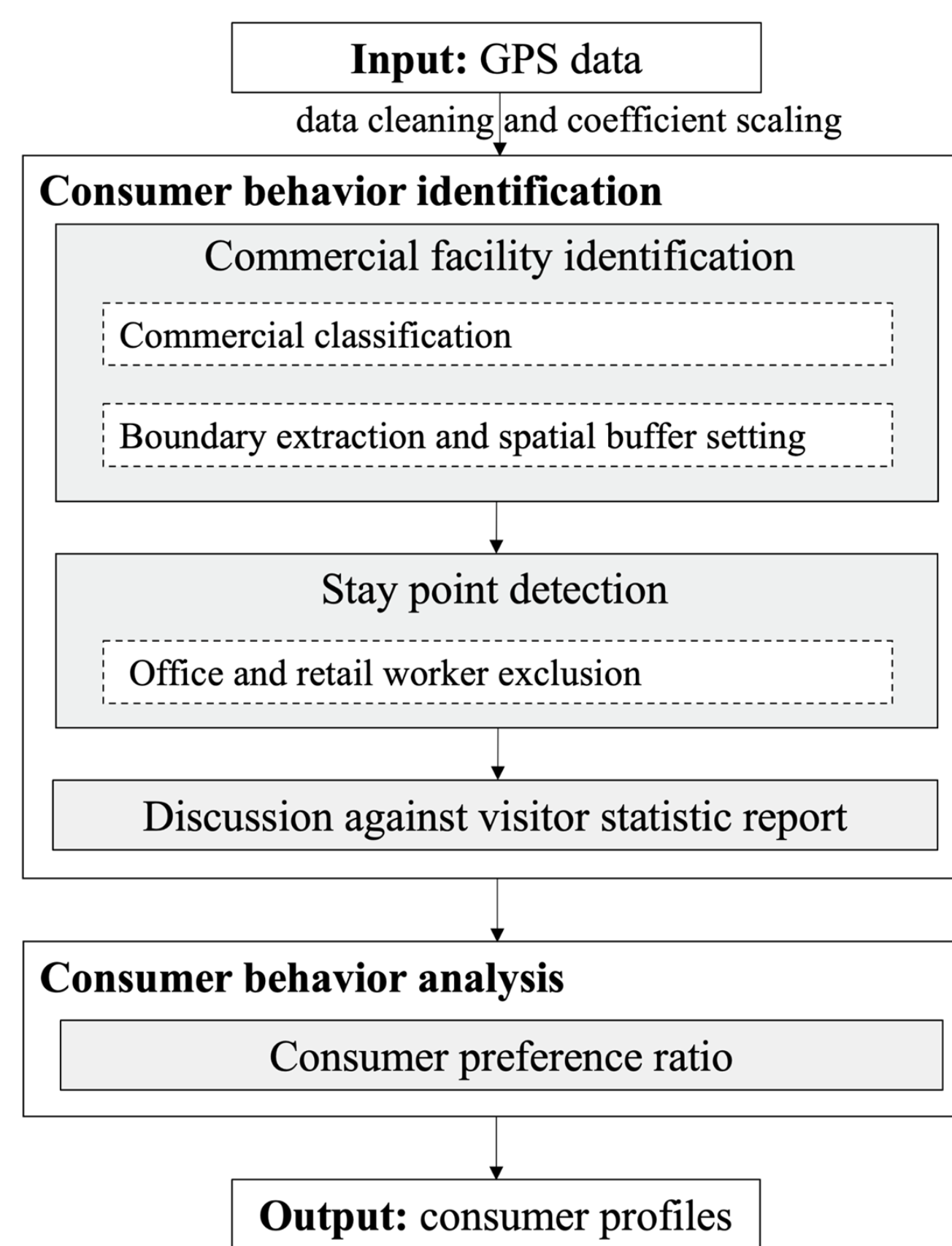Fig. 4 Visit frequency (left: shopping centers, right: shopping streets)

Fig. 5 Consumer preference ratio (shopping centers)
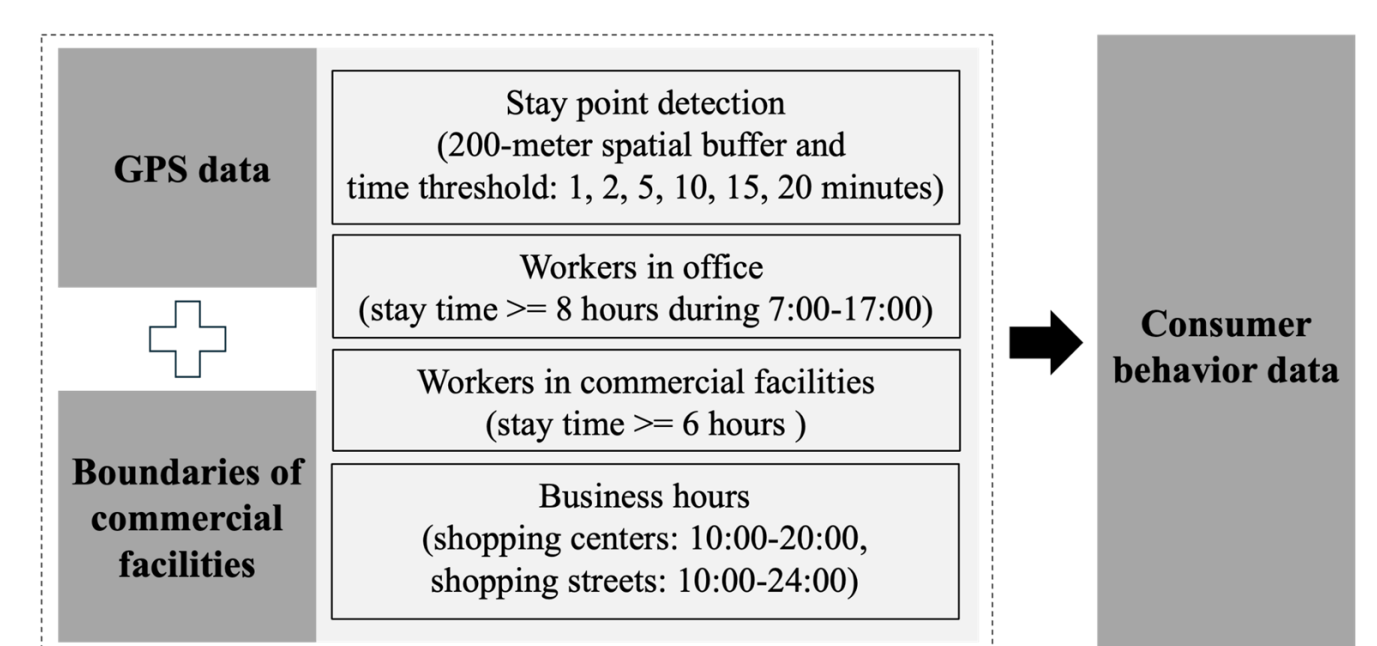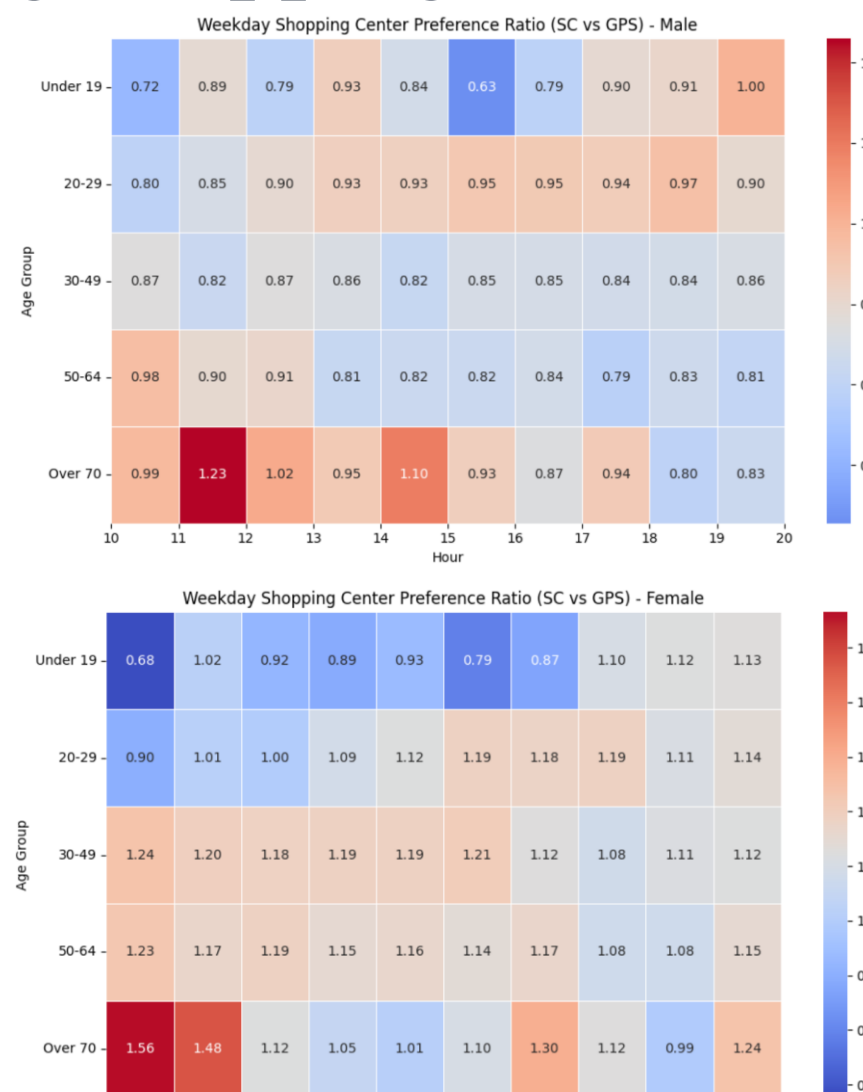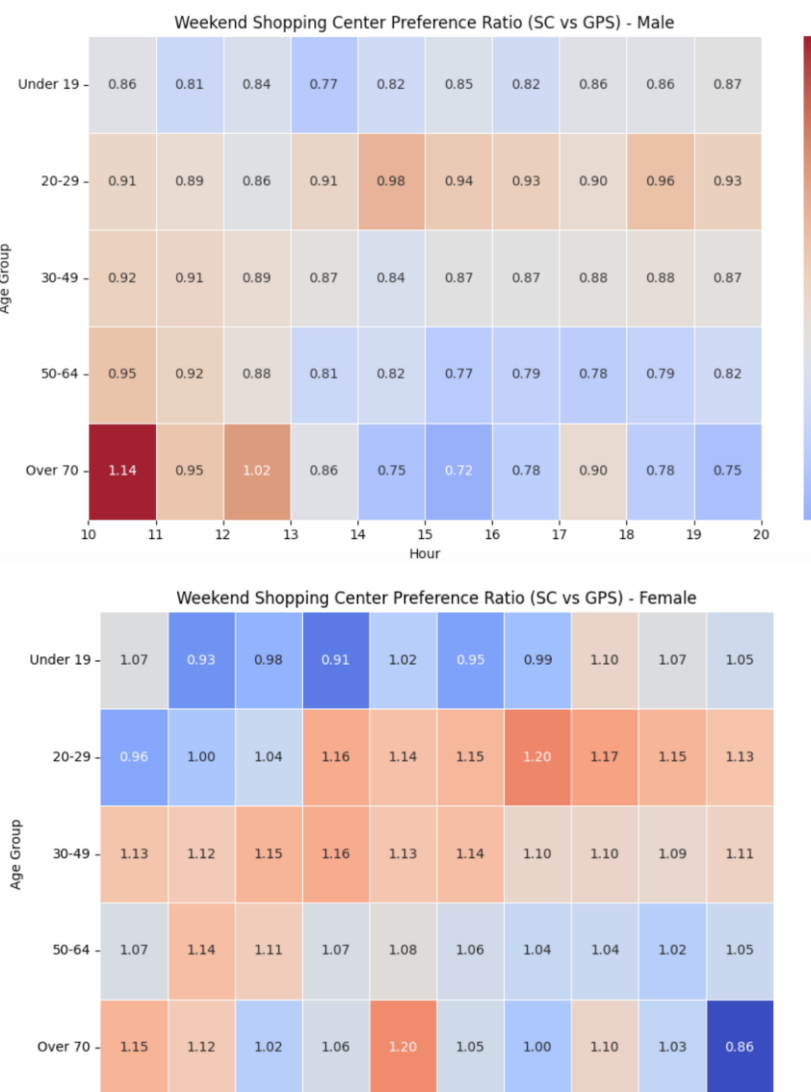

Fig. 6 Consumer preference ratio (shopping streets)

Conclusion

Consumer behavior across different age and gender groups is significantly influenced by shopping centers and shopping streets, and by the time of day. However, further research is needed to clarify which built environment characteristics of these facilities most affect consumer decision-making.