東京大学　関本研究室 / Sekimoto Lab. IIS, the University of Tokyo.

Enhancing geospatial retail analysis by integrating mobility behavior

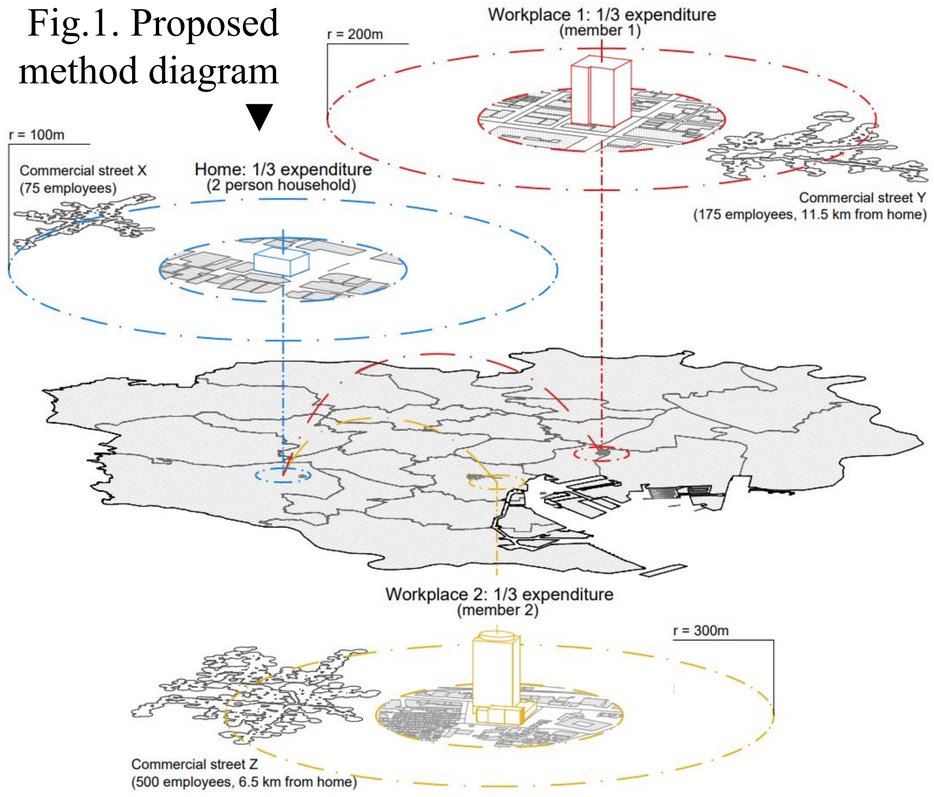
Santiago Garcia, Yuya Shibuya, Yoshihide Sekimoto

Background

Street commerce is fundamental to have a lively and convenient cities, but it's economic sustainability is under threat given the rapid changes in the retail environment in recent years.

To grasp possible solutions, first e try to understand the impact of consumer behavior in the brick-and-mortar retail sector by combining census information with consumer surveys and a preexisting mobility simulation.

Fig.1. Proposed method diagram ▼



Population's disposable income

We improve traditional analysis by integrating commuting behavior to better understand population's expenditure locations.

Fig.2. Only at residence location. ▼

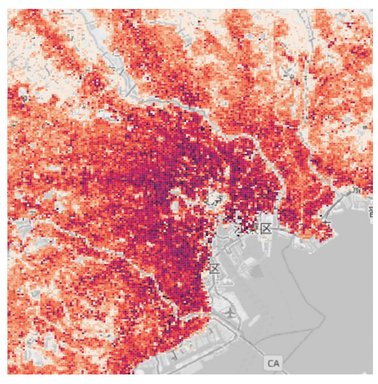
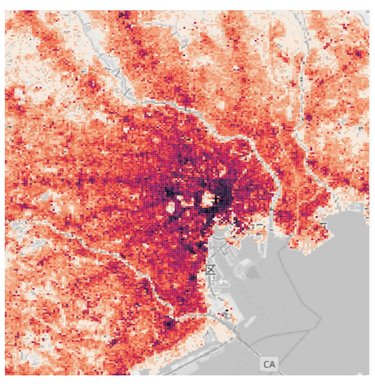


Fig.3.With commuting behavior. ▼



Method

Using the traditional method and our proposed method (introducing commuting behavior), we estimate population's disposable income around commercial streets (Shotengai) and compare it with the actual revenue reported by Shotengai in Tokyo.

Potential revenue: Huff model.

The Huff model is the standard method to estimate potential revenue of stores. It does so by estimating market share comparing a store's attraction and its distance to potential consumers relative to other competing stores.

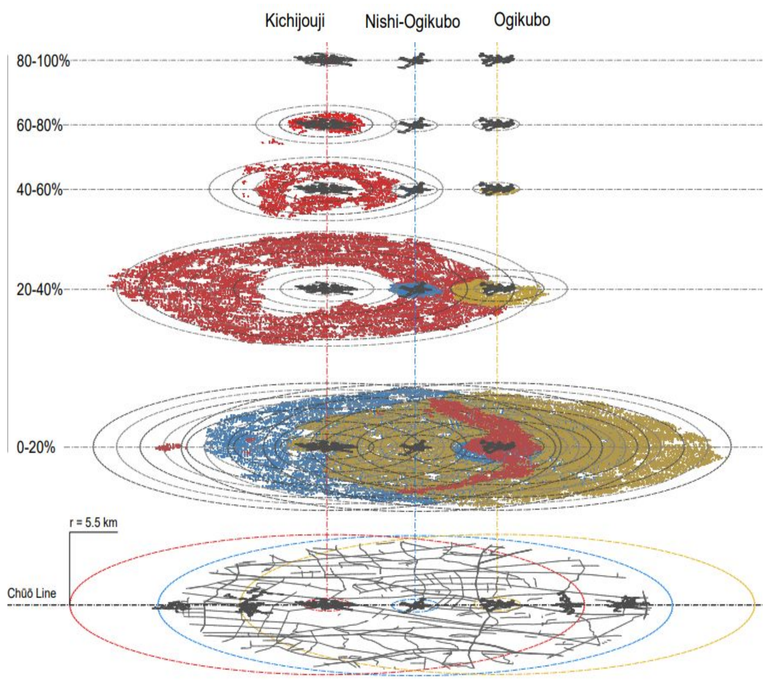


Fig.4. Market share Huff retail gravitation ▶

The impact of footfall.

We then estimate market share by combining the attraction of commercial streets with synthetic pedestrian trajectory counts, using them as an alternative measure of proximity to identify their influence over the context.

Fig.5.
Weights from pedestrian trajectories ▶

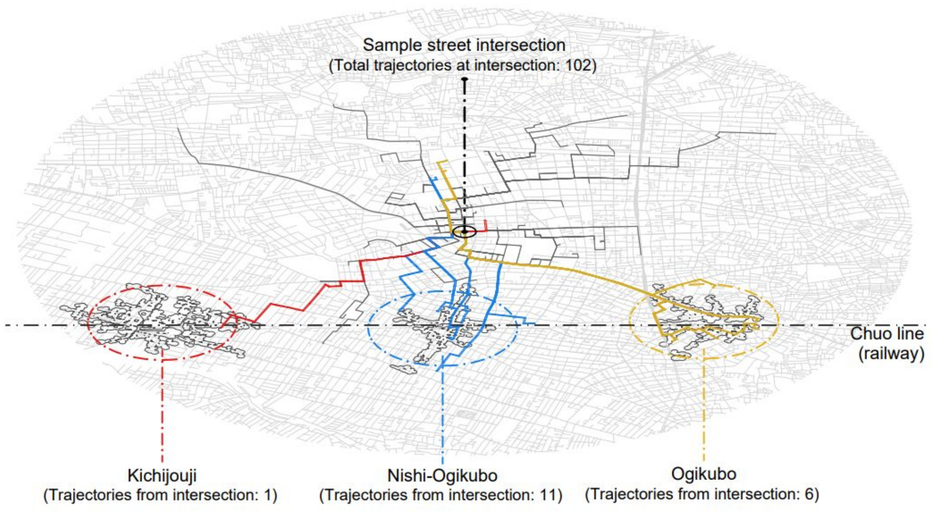
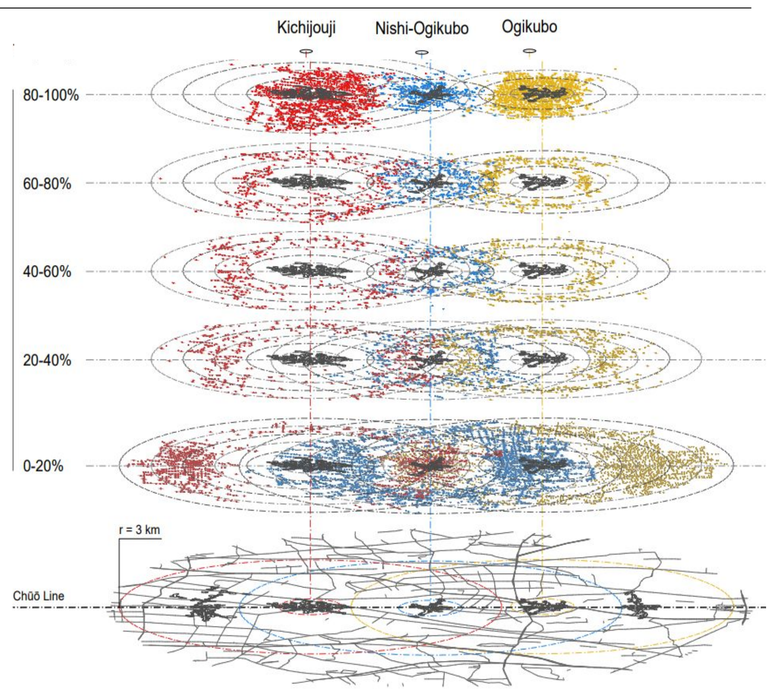


Fig.6. Market share pedestrian trajectories ▶



Results

700 commercial streets analyzed for Tokyo and three study areas.

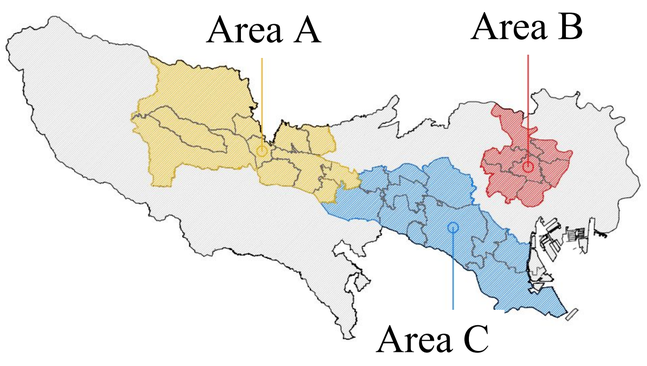


Table 1. Food-related disposable income to actual revenue in Tokyo and case study areas

Model	Tokyo		A		B		C	
	R^2	Std. Err.	R^2	Std. Err.	R^2	Std. Err.	R^2	Std. Err.
Traditional-Huff	0.41*	4.64	0.70*	2.35	0.61*	4.88	0.66*	4.08
Commuter-Huff	0.74*	3.1	0.72*	2.28	0.91*	2.32	0.63*	4.2
Trajectory-Size	0.56*	4.01	0.72*	2.25	0.60*	4.98	0.42*	5.27

*p<0.001

Conclusion

Integrating commuter behavior significantly increases R^2 of disposable income to actual revenue

Additionally, the trajectory-based market share model proved useful to identify the pedestrian reliance of different Shotengai.

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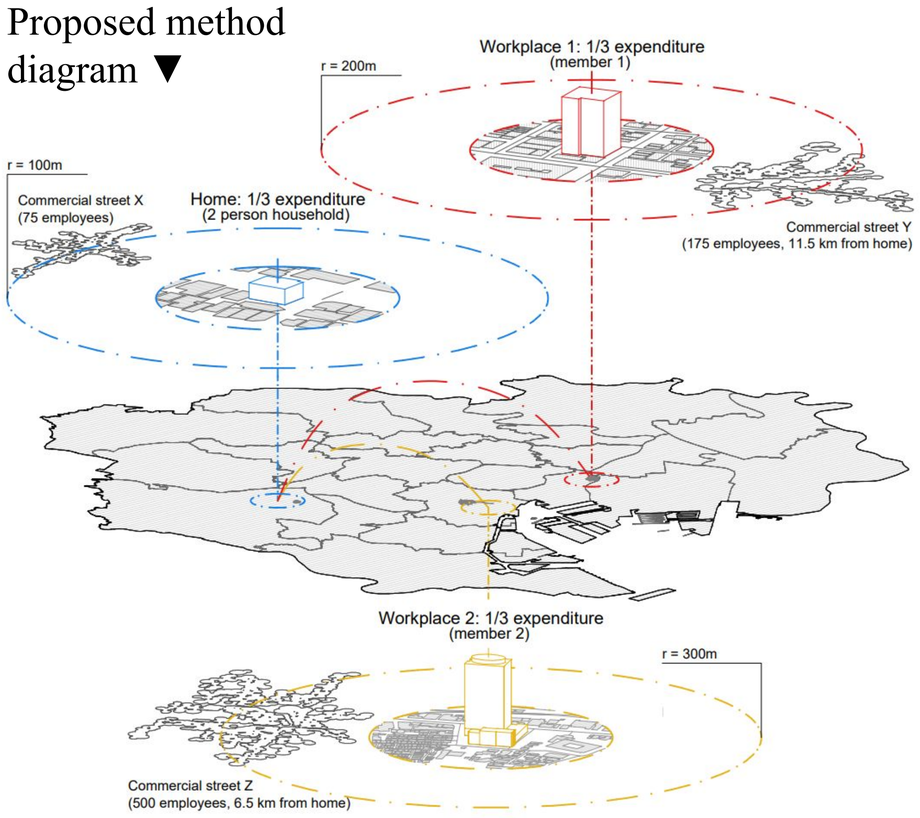
Background

Brick-and mortar retail is a fundamental element towards more socially, economically and environmentally sustainable cities, but it has experienced many recent shocks, such as the rise of online shopping and the recent Covid-19 pandemic, which threaten its economic viability. To be able to guarantee the continuity of this retail format given its contribution to urban liveliness, we need to understand where their customers come from and what is their disposable income. To do this we use the Retail Gravitation model, combining it with a mobility simulation (Pseudo-Pflow) to conduct such analysis.

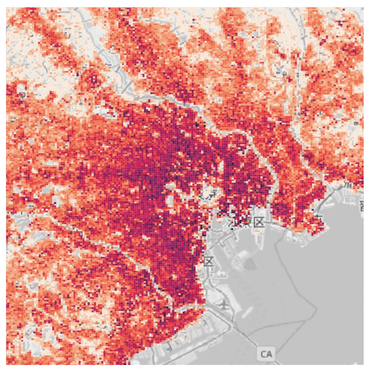
Proposed method diagram ▼



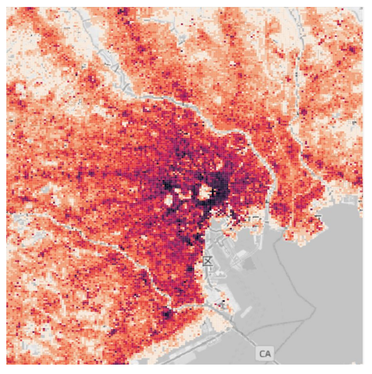
Population's potential expenditure

We improve traditional analysis by integrating commuting behavior which allows us to visualize a major concentration of disposable income in Tokyo's central districts.

Only at the residence location. ▼



Modeling commuting behavior. ▼



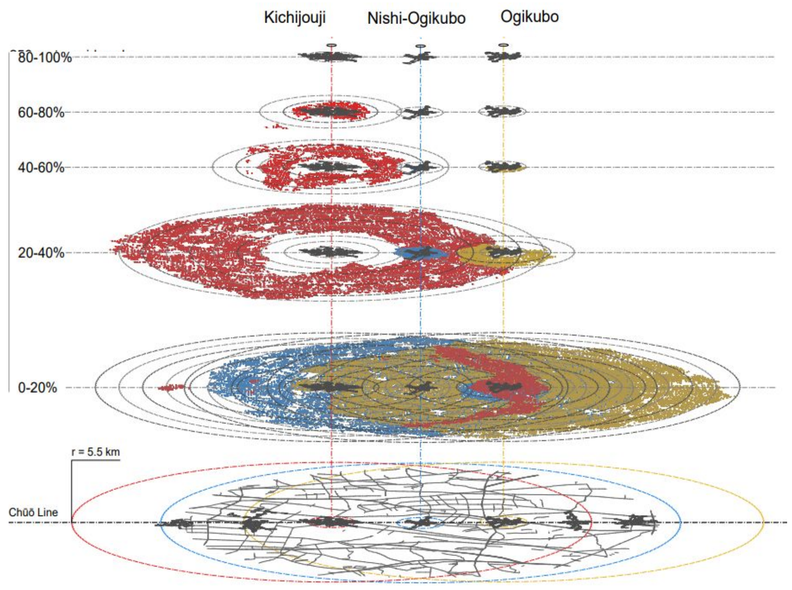
Method

Estimating potential revenue using the Huff model.

The Huff model of retail gravitation is the most conventional method used to estimate revenue in the retail geometry field. It estimates the attraction of a given store(s) relative to other competing store(s) estimating the market share based on the distance and the size/attraction of each store.

We use this framework to estimate the disposable income of the population surrounding commercial streets (Shotengai) both using the traditional method (residence only) and our proposed method (with commuting behavior), and comparing such potential expenditure with the actual reported food-related retail revenue in multiple Shotengai in the Tokyo prefecture.

Fig.4. Market share Huff retail gravitation ▶



Using footfall to estimate market share.

We developed a method to estimate market share using the size of commercial accumulations and synthetic pedestrian trajectory counts to approximate how football influences revenue in brick-and-mortar retail.

Fig.5.
Weights from pedestrian trajectories ▶

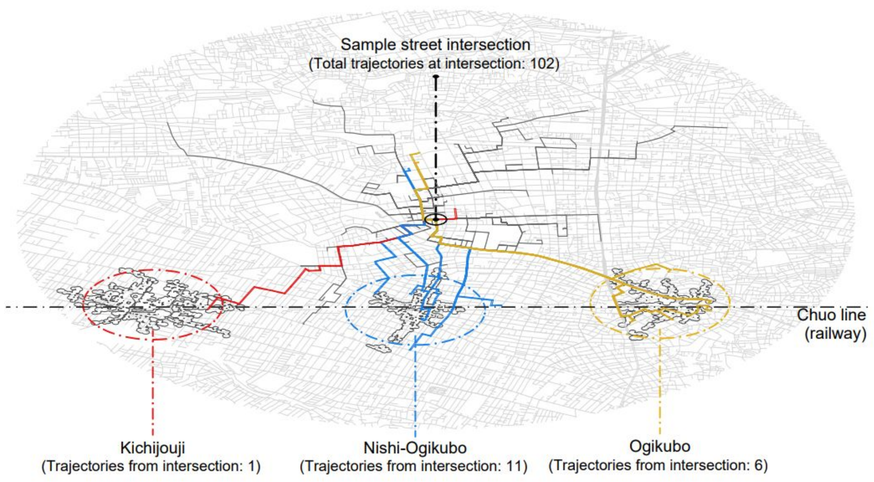
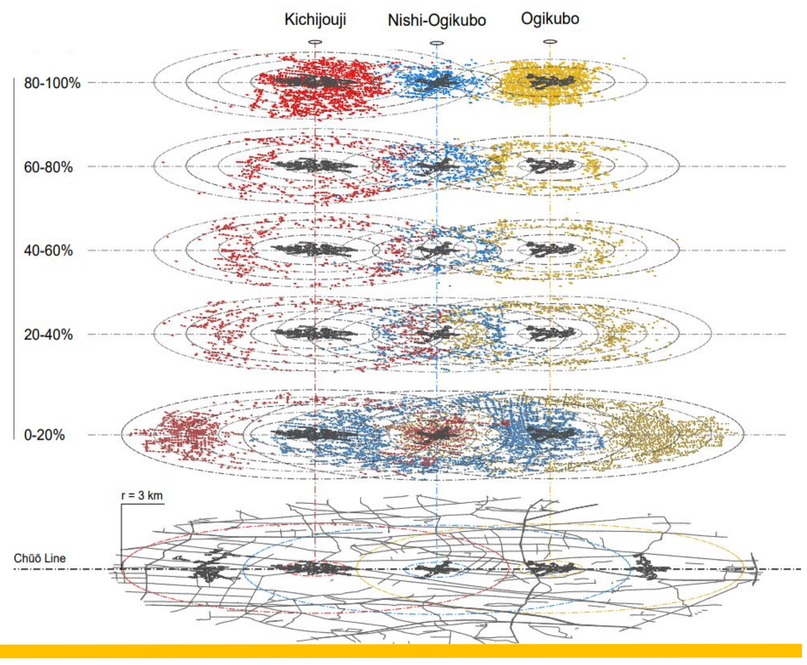


Fig.6. Market share pedestrian trajectories ▶



Results

700 commercial streets were analyzed in using regression analysis of the potential expenditure to the actual revenue. First for all Tokyo prefecture and then for three case study areas.

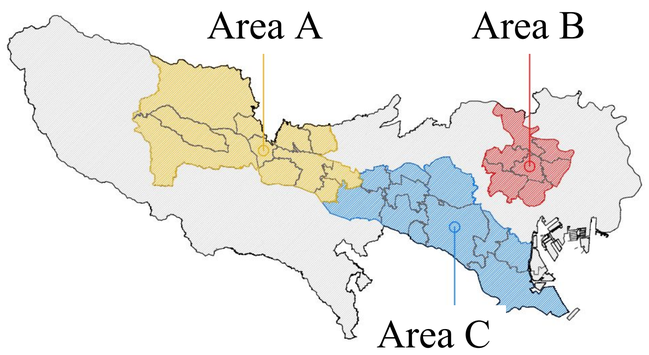


Table 1. Potential exp. to actual revenue Tokyo level

Model	Traditional-Huff		Commuter-Huff		Trajectory-Only		Trajectory-Size	
	R^2	Std. Err.	R^2	Std. Err.	R^2	Std. Err.	R^2	Std. Err.
Str.Int.	0.41***	4.63	0.74***	3.10	0.17***	5.49	0.56***	4.01

Table 2. Potential exp. to actual revenue, study areas.

Model	Area A (Setagaya)		Area B (Bunkyo)		Area C (Outskirts)	
	R2	Std. Err.	R2	Std. Err.	R2	Std. Err.
Trad-Huff	0.70***	2.35	0.61***	4.88	0.66***	4.08
Comm-Huff	0.72***	2.28	0.91***	2.32	0.63***	4.20
Tj-Size	0.72***	2.25	0.60***	4.98	0.42***	5.27

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Conclusion

Integrating mobility behavior results in a significant R^2 increase from potential expenditure to actual revenue of commercial streets using the Retail Gravitation Model when integrating commuting behavior (Commuter-Huff model).

Furthermore, when the correlation from the proposed trajectory-based market share model approximates that of the Commuter Huff model, it proves useful to determine which commercial streets are more pedestrian reliant;