

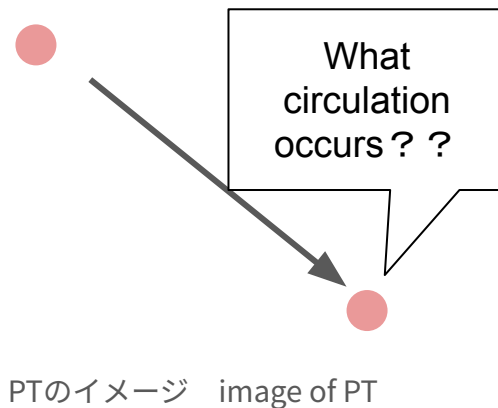
Measuring a City's "Uniqueness": A Two-Stage Behavioral Model

東大交通研Bチーム University of Tokyo Behavior in Networks lab. B team

社会的背景 Social Background

Current Limitation: While **PT data** captures **macro-level mobility** across metropolitan areas, it lacks detailed insights into stay durations and activity patterns within visited areas.

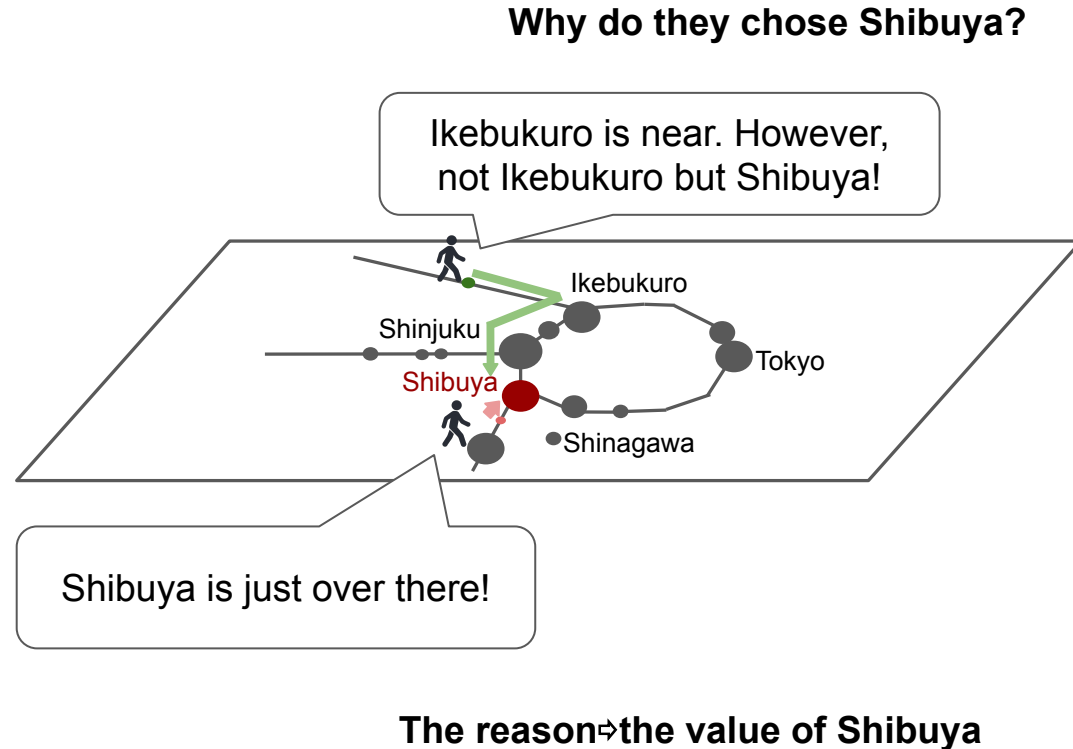
Challenge: This limits our ability to quantitatively forecast micro-level behavioral changes and the economic impacts of transport policies.



渋谷PP調査（2023）GPSデータより

Why Choose a Specific City Despite Higher Travel Costs?

- Why do people visit destinations that **seem irrational** when considering travel costs (time & distance)?
- How does this deliberate **"purpose-driven choice"** influence **their behavior after arriving** at the destination?
- A city's true attraction lies in being **"deliberately chosen"**—Quantifying this **"deliberate visit volume"** serves as **a new indicator** for distinctive urban design.

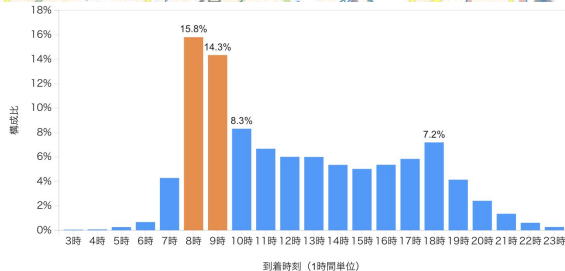


Data...PP and PT data

2008 Shibuya Person Trip (PT) Data

Visitors to Shibuya were defined as individuals who visited either of the two small zones containing Shibuya Station.

Work-related trips accounted for more than 40% of all visit purposes. The purposes analyzed in this study—shopping, dining/entertainment, sightseeing, and leisure—accounted for **30.2%** of all visits.



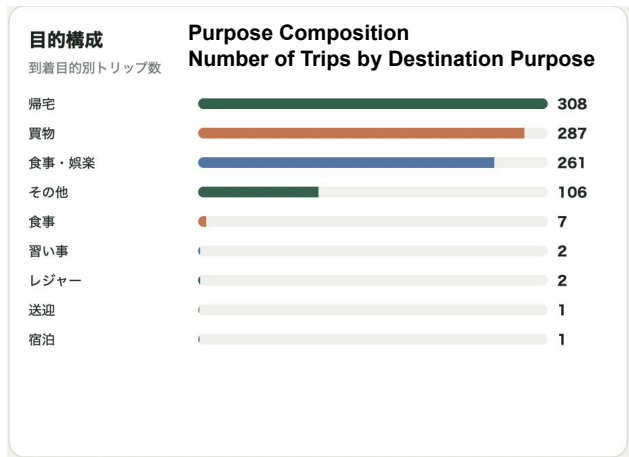
訪問目的



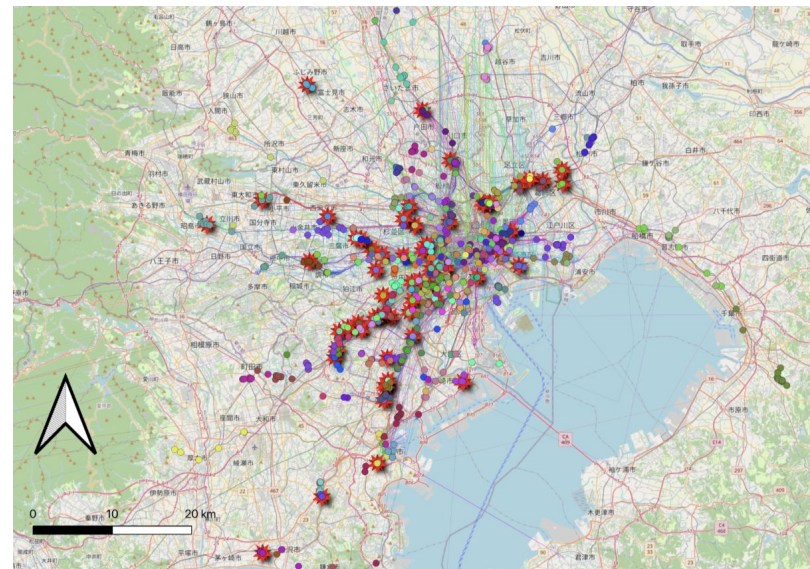
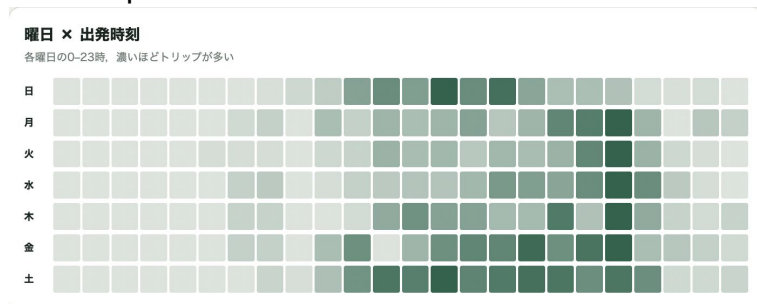
区分	0ではないセル	0のセル	0の比率
全目的	47,246	135,083	74.09%
買い物 (Purpose 4)	7,661	174,668	95.80%
食事・娯楽 (Purpose 5, 6)	8,127	174,202	95.54%

In the purpose-specific OD matrices, more than 95% of the cells were zero..

2021,2023PP data



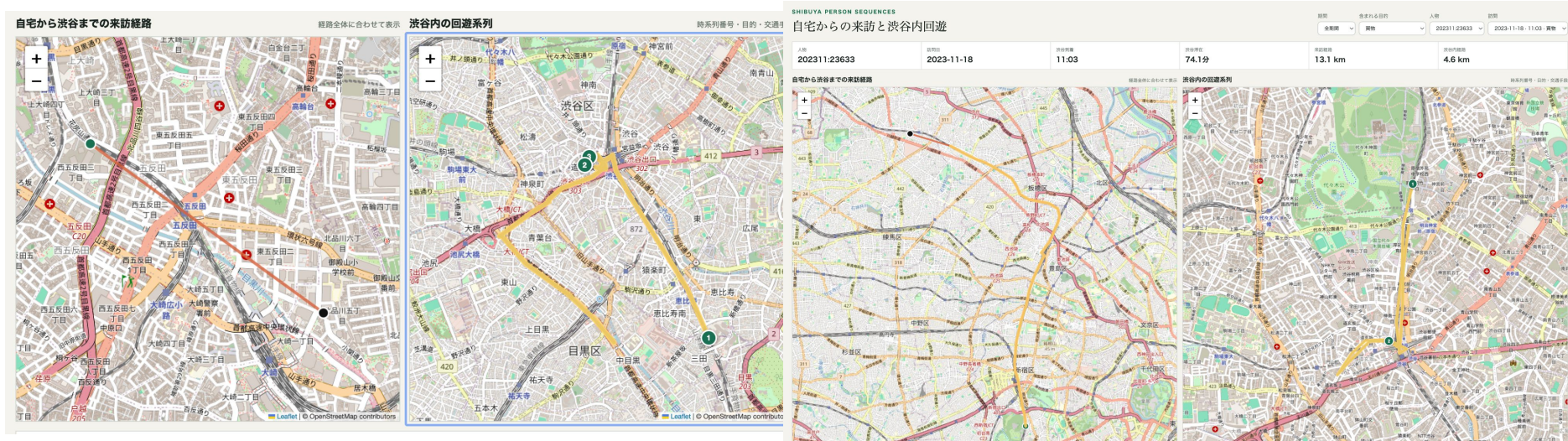
Trip purpose breakdown: Shopping, dining, and leisure trips account for the vast majority of trips.



Estimated home location (the starting point of a trip and a location frequently recorded in the data)

← More trips occur from the afternoon to the evening (x-axis: time of day).

Travel to Shibuya and Circulation Behavior



→ Among visitors who “choose to come” to Shibuya, their roaming behavior includes visits to distinctive areas unique to Shibuya, such as Dogenzaka.

Methodology There are 2 steps!!

① For each origin and trip purpose of PT data, we predict destination choices across the metropolitan area, where a Graph Neural Network calculates the utility score

$$V_{odp} = f_{\theta}(Z_{odp}, p)$$

Using this utility score, we obtain the choice probability

$$\hat{P}(d \mid i, p) = \frac{\exp(V_{idp})}{\sum_{k \in D} \exp(V_{ikp})}$$

From which we calculate

$$C_{ip} = \log \left(\frac{\hat{P}(\text{Other} \mid i, p)}{\hat{P}(\text{Shibuya} \mid i, p)} \right)$$

② The utility of visitor i selecting district z in Shibuya for purpose p is

Baseline attractiveness of each area $\times$ purpose combination

$$U_{izp} = \alpha_{zp}$$

$$+ \gamma C_i I(p = \text{leisure})$$

Are individuals with higher C_i more likely to choose leisure activities in Shibuya?

$$+ \rho_{\text{shop}} C_i A_z I(p = \text{shop})$$

For shopping trips, how does C_i affect the evaluation of accessibility to each area?

$$+ \rho_{\text{leisure}} C_i A_z I(p = \text{leisure})$$

For leisure trips, how does C_i affect the evaluation of accessibility to each area?

$$+ \delta_{\text{est,shop}} C_i X_{\text{est},z} I(p = \text{shop})$$

Do shopping visitors with higher C_i tend to prefer areas with a high concentration of stores?

$$+ \delta_{\text{building,shop}} C_i X_{\text{building},z} I(p = \text{shop})$$

Do shopping visitors with higher C_i tend to prefer areas with a higher building density?

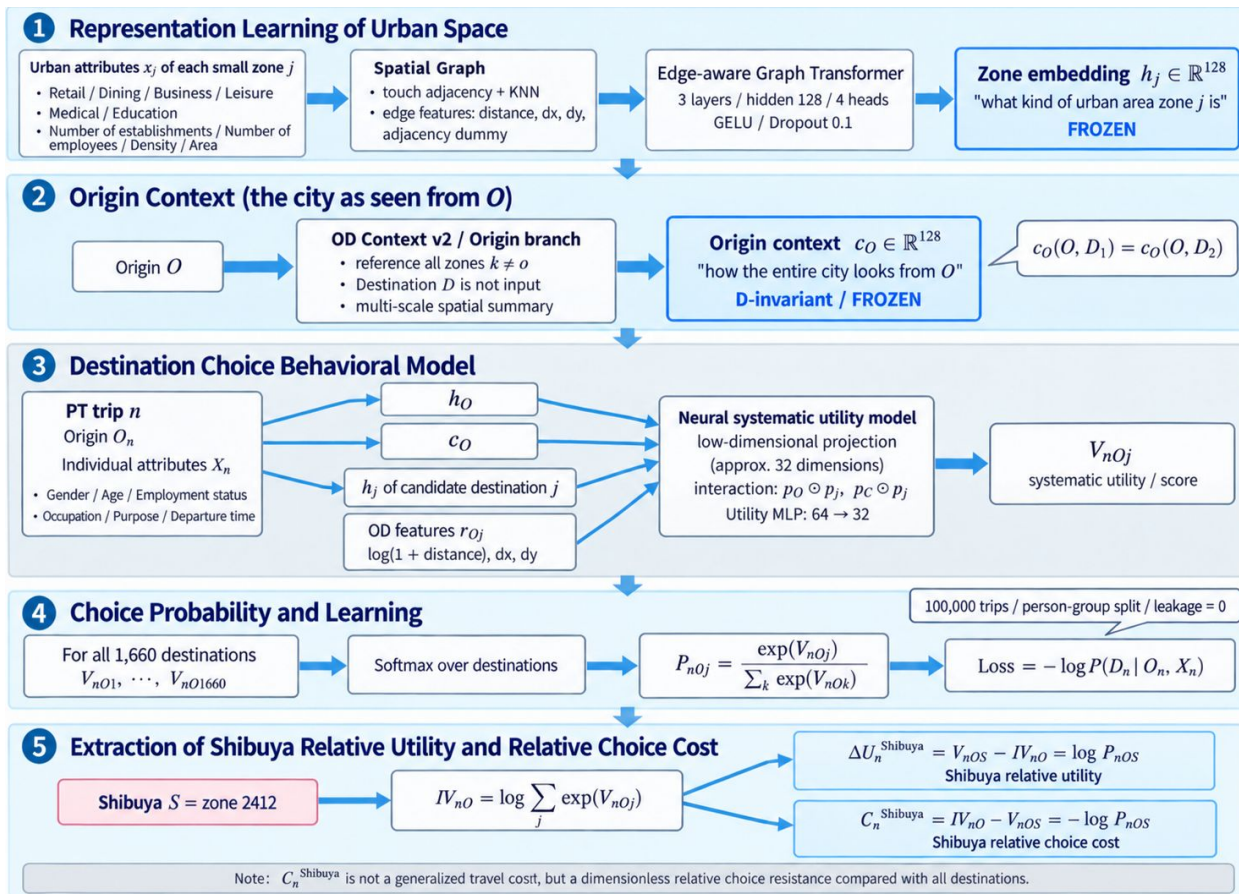
$$+ \delta_{\text{foodent,leisure}} C_i X_{\text{foodent},z} I(p = \text{leisure})$$

Do leisure visitors with higher C_i tend to prefer areas with a higher concentration of restaurants?

$$+ \delta_{\text{building,leisure}} C_i X_{\text{building},z} I(p = \text{leisure})$$

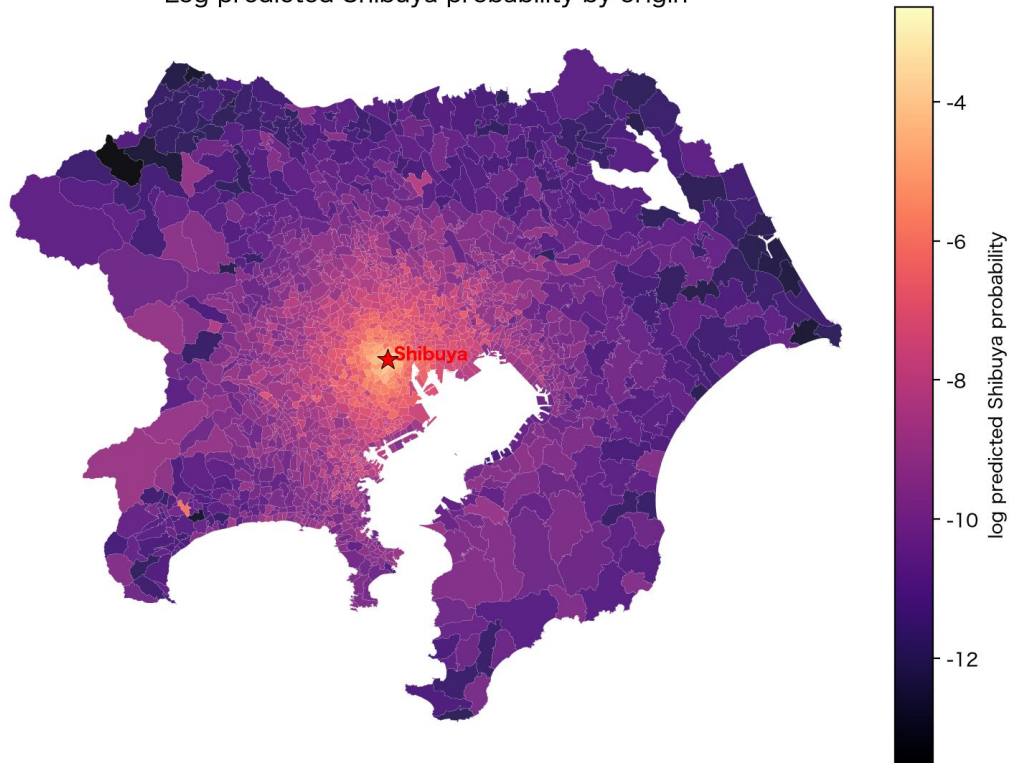
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NN in the first stage

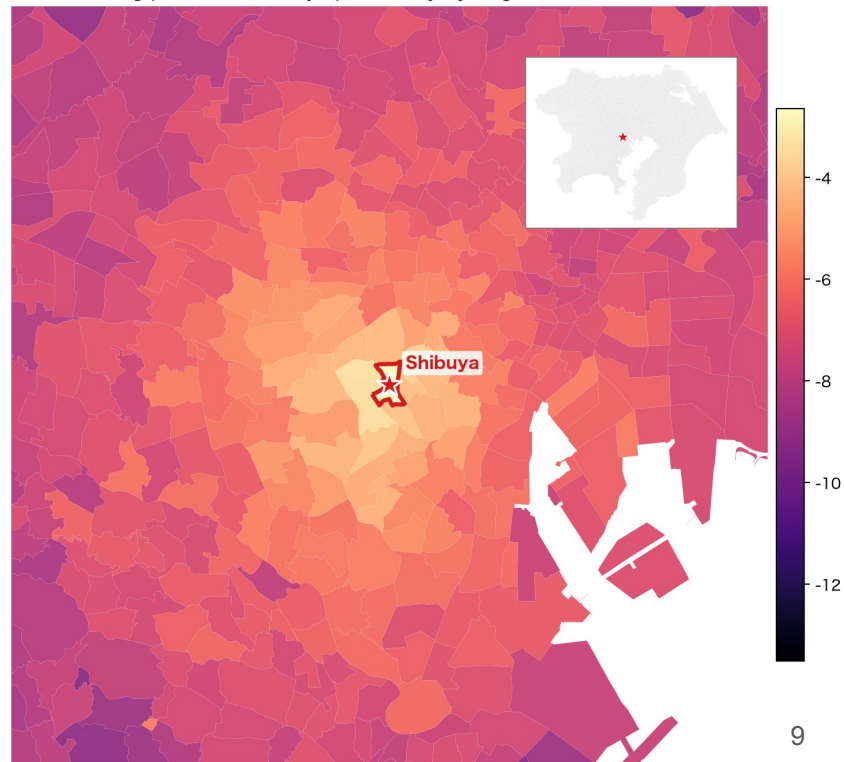


Calculated cost

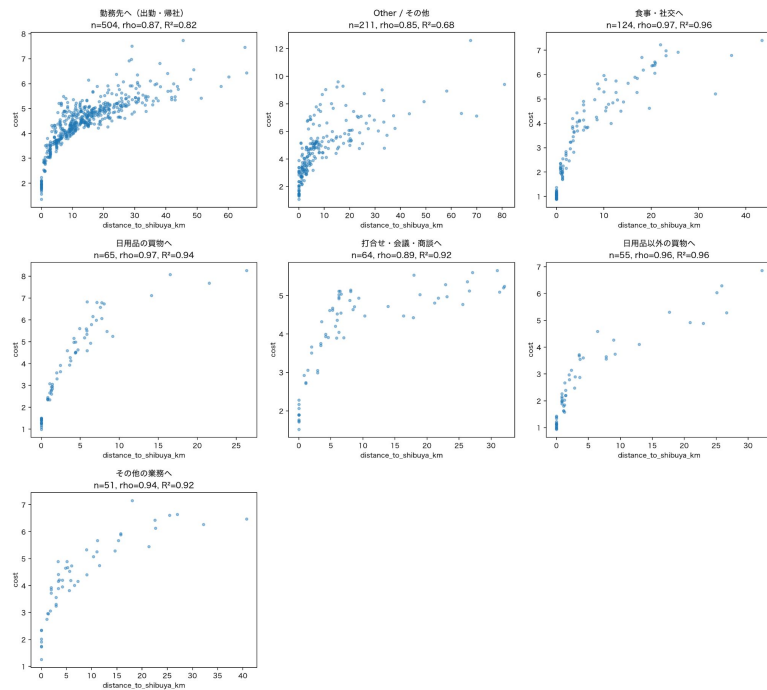
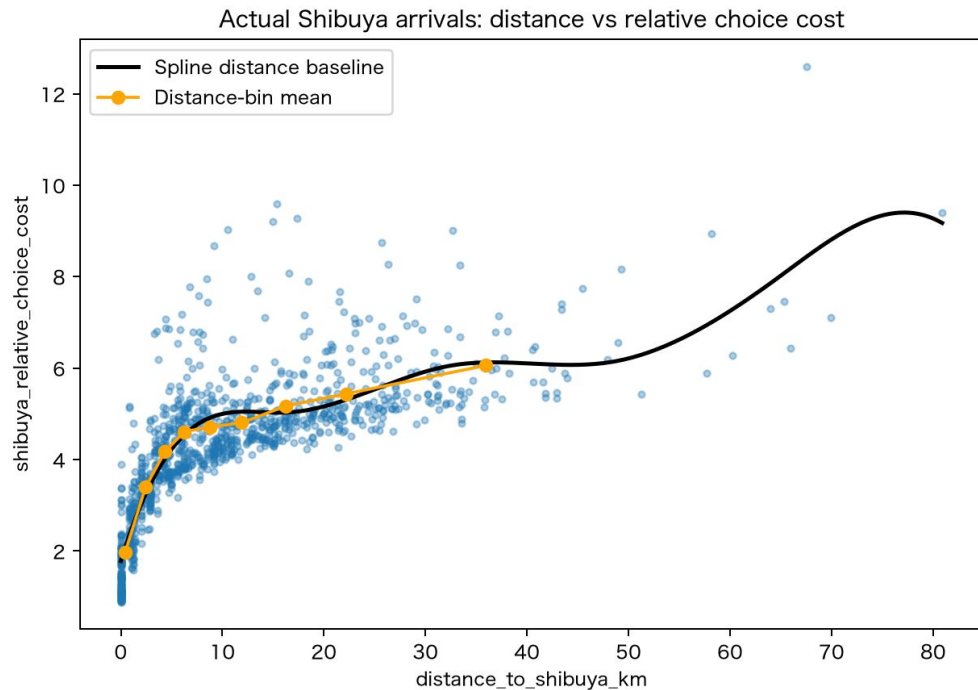
Log predicted Shibuya probability by origin



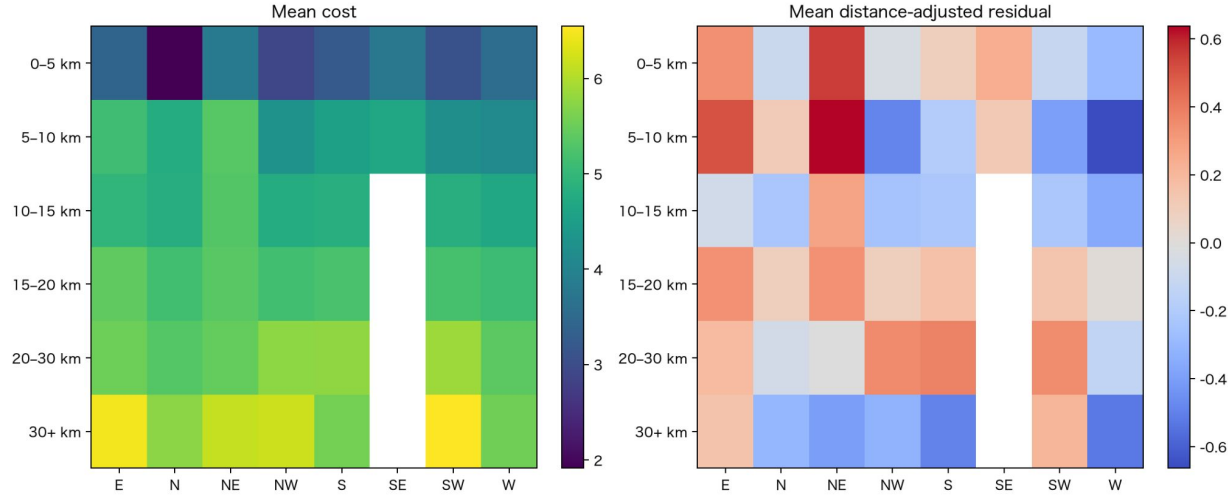
Log predicted Shibuya probability by origin (15 km zoom)



Distance determines the lower limit of costs—the influence of the party withholding the resource may be significant.

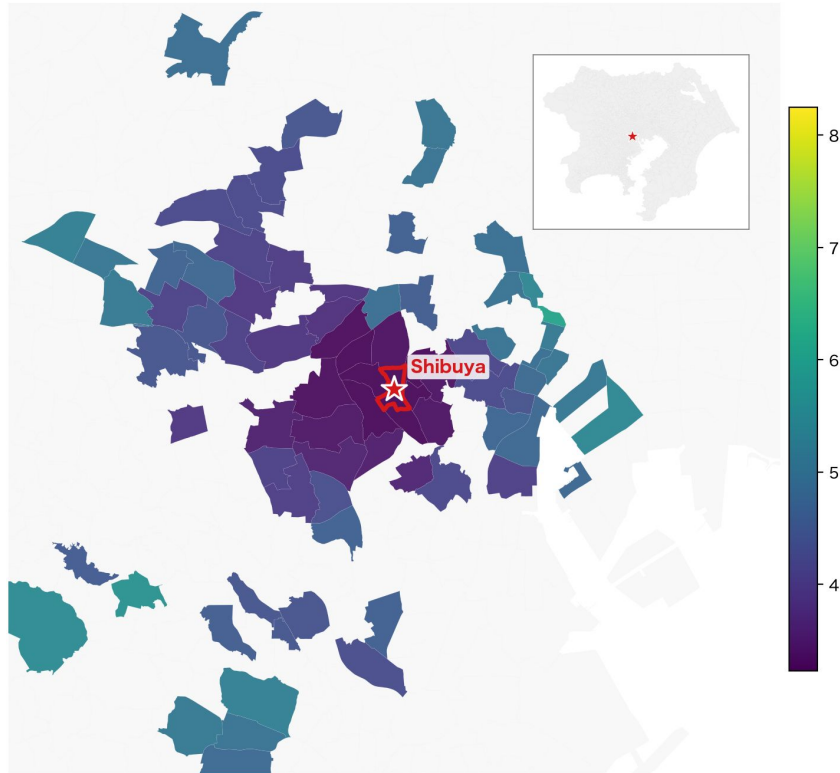


Cost trends by direction

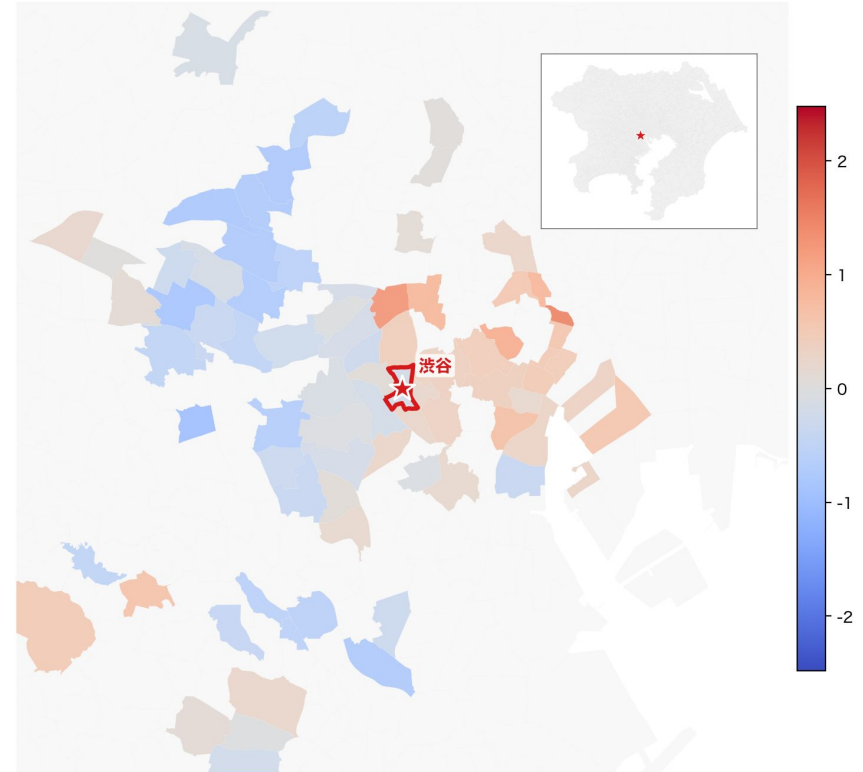


The cost differences cannot be explained by distance alone

Shibuya visitors: mean relative choice cost by origin (15 km zoom)



距離調整後の渋谷相対選択コスト残差 (15km圏)



4 Run result

shibuya-full-without-sakuragaokacho-no-asc_20260909-095014__1b8d136a

推定指標			metrics		
修正済み尤度比 ρ^2	赤池情報量基準 (AIC)	ベイズ情報量基準 (BIC)	condition_number	収束	design_rank
0.03	767.65	806.08	307.07	はい	13.00
gradient_norm	最終尤度	初期尤度	収束メッセージ	n_alternatives	サンプル数 (ケース)
0.00	-370.82	-393.71	Optimization terminated successfully.	16	142
パラメータ数	n_users	尤度比 ρ^2	ridge_asc	standard_error	
13	63	0.06	0.00	user_clustered_sandwich	

推定係数							parameters
説明変数	パラメータ	標準誤差	t値	p値	lower	upper	
control:distance_shop	0.22	0.36	0.61	0.544	-0.4895696482646009	0.9282702709647778	
control:distance_leisure	0.02	0.31	0.07	0.947	-0.5777671925437667	0.6185515798907805	
control:establishment_shop	0.20	0.45	0.46	0.647	-0.6690665184159934	1.0771651516820464	
control:building_shop	0.30	0.36	0.84	0.401	-0.404430265140316	1.0117313854916397	
control:foodent_leisure	0.38	0.32	1.19	0.235	-0.24936797218174928	1.014310472029266	
control:building_leisure	0.09	0.41	0.22	0.825	-0.7163409749633165	0.8985135638592894	
gamma:competition_x_leisure	-0.20	0.19	-1.08	0.281	-0.5742520468018995	0.16656224292858696	
rho:competition_x_distance_shop	-0.11	0.27	-0.42	0.673	-0.6354776587791142	0.4103156084910282	
rho:competition_x_distance_leisure	0.03	0.19	0.13	0.894	-0.35426778195079905	0.4061224967989682	
delta:competition_x_establishment_shop	-0.64	0.37	-1.72 [†]	0.086	-1.365965849527262	0.08974387247489413	
delta:competition_x_building_shop	0.49	0.29	1.69 [†]	0.091	-0.0775377524172779	1.0555866992635368	
delta:competition_x_foodent_leisure	-0.07	0.31	-0.21	0.832	-0.6753498748379203	0.5434334707963522	
delta:competition_x_building_leisure	0.08	0.33	0.25	0.805	-0.5606392645685155	0.722012896164515	

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Thank you for your attention!

Appendix(日本語併記)

