UTokyo_BMDS(原研究室)

最終発表 / Final Presentation

小野 輝 / Hikaru Ono, M1
佐藤 瑠空 / Ryuku Sato, B4
古谷 達拡 / Tatsuhiro Koya, B4
本澤 聡一郎 / Soichiro Honzawa, M1
金 性勳 / Sunghun Kim, M1
朴 承愛 / Chengai Piao, M1
劉 桐羽 / Tongyu Liu, M1

背景 / Background

【JR渋谷駅 新南口改札の特徴】

- 利用者数は他と比べて少ない
- 周辺施設も中央改札、ハチ公改札付近ほど充実していない

▶ 新南口改札の利用を促すインセンティブ配布や課金によって、**施設の充実に先立つ人流の形成が期待**できる

⬌ 渋谷駅周辺の経路全てにインセンティブや課金を定義することは非現実的

人流のボトルネックである改札への課金 → 渋谷駅利用者の新南口改札方面への誘導 → 渋谷という都市全体の制御を目指す

人流のボトルネックである改札への課金 → 新南口改札付近の回遊性の向上 → 渋谷という都市全体の制御を目指す

Background

【Features of the JR Shibuya Station New South Exit】

- Passenger volume is lower compared to other exits.
- Surrounding facilities are not as extensive as those near the Central Exit or Hachiko Exit.

▶ By distributing incentives or implementing charges to encourage the use of the New South Exit ticket gate, it is anticipated that a flow of people can be generated in advance of the facility's enhancement.

⬌ It is unrealistic to define incentives or charges for every possible route around Shibuya Station

Imposing charges at ticket gates, which act as bottlenecks for passenger flow

→ Guidance of Shibuya Station users towards the new south exit ticket gate

→ Improving circulation near the New South Exit ticket gate

→ Aiming to control the entire city of Shibuya

Ref: Relative locations of Shibuya Station and the New South Exit ticket gate.

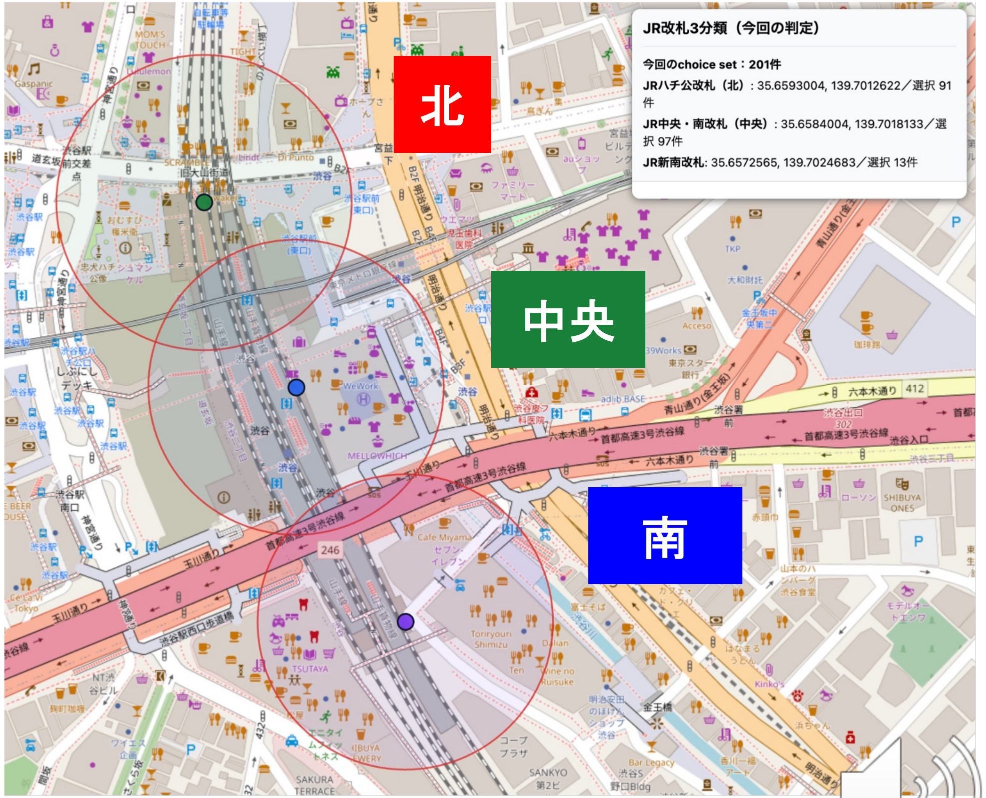
本発表における各改札の呼称と代表改札点の位置

本発表においては,

- 北＝ハチ公改札エリア
- 中央＝中央改札・南改札エリア
- 南＝新南改札エリア

を指すものとする

- jr_hachiko, JRハチ公改札（北）
  35.659300, 139.701262
- jr_chuo_minami, JR中央・南改札（中央）,
  35.658400, 139.701813
- jr_shinminami, JR新南改札,
  35.657256, 139.702468



Designations of each ticket gate and the locations of the representative gate points for this project

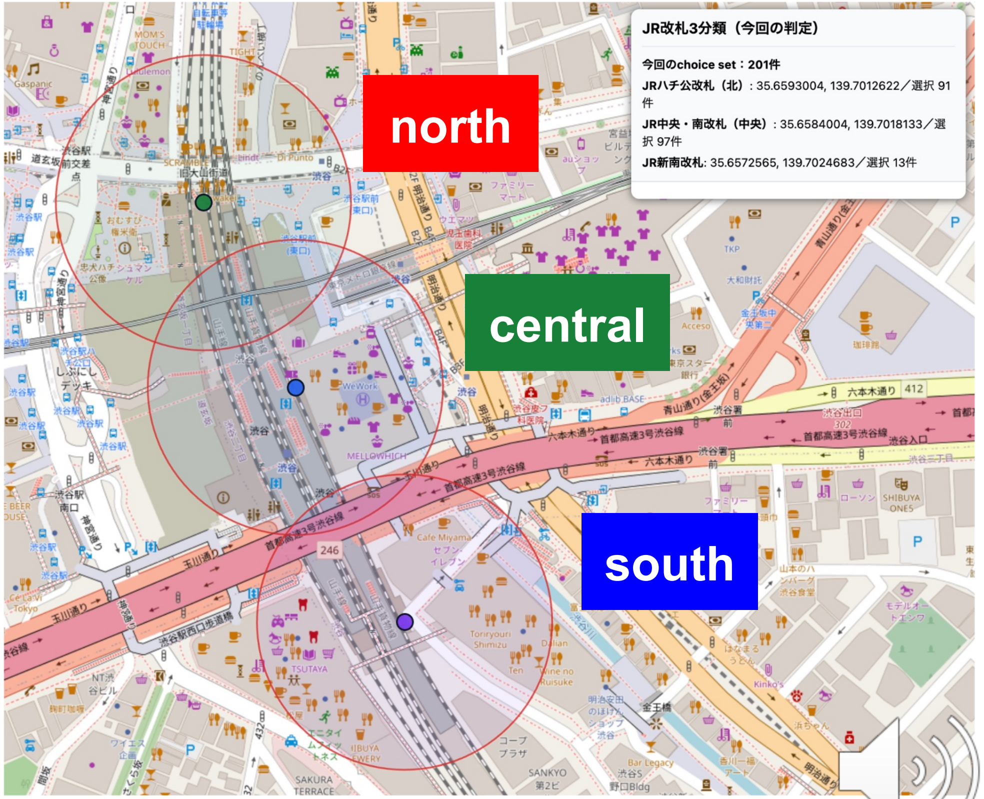
In this project, the following terms refer to these specific areas:

- north＝Hachiko Ticket Gate area
- central＝Central Ticket Gate / South Ticket Gate area
- south＝New South Ticket Gate area

➢ jr_hachiko,　Hachiko Ticket Gate area (north)
35.659300,　139.701262

➢ jr_chuo_minami,　Central Ticket Gate / South Ticket Gate area　(central)　,
35.658400,　139.701813

➢ jr_shinminami,　New South Ticket Gate area，　35.657256,　139.702468



本課題で検証する仮説

- 金銭的なincentiveを与えた場合に，現実的な値で利用者の行動変容を促せるか？
- （渋谷を訪れるメイン層がよくいく施設である）カラオケ・フィットネスジムの存在は，新南口への誘導を担えるか？
- 渋谷駅南側周辺には，多くのオフィスビルがあるため，co-working施設の存在が来訪者増加に必要なのではないか？
- 一般に，利用者や改札方向に対して，接触する店舗や施設の量だけではなく質・種類がハチ公方面と南側の大きな違いであり，これが来訪者の人数に影響しているのではないか？

Hypothesis to be tested in this project

- Can financial incentives effectively encourage behavioral changes among users at realistic price points?
- Can facilities frequently visited by the primary demographic of Shibuya—such as karaoke and fitness gyms—serve to draw people toward the New South Exit?
- Given the concentration of office buildings in the area south of Shibuya Station, might the presence of co-working facilities be essential for increasing visitor numbers?
- In general, a major difference between the Hachiko area and the southern area lies not merely in the quantity of shops and facilities accessible to users or those exiting the ticket gates, but in their quality and variety; could this be a factor influencing visitor numbers?

使うデータについて

Shibuyaの2023.01PPデータおよび2023.11PPデータを合成する.

- 記録人は全て異なるものとする
- 1月と11月のデータにおける人流は変わらないものと仮定した

<u>データの基礎情報</u>

- 件数：654件
- 選択肢行：1962行 (654件*3選択肢)
- 人数：182人
- 改札i=前ページ参照
- 利用者id: n
- トリップ目的P（＝110帰宅，200/210娯楽，300/310仕事，それ以外）

About the data used

The Shibuya PP data from January 2023 and November 2023 are combined.

- All recorded individuals are treated as distinct.
- It is assumed that human flow patterns remained unchanged between January and November.

<u>Basic Data Information</u>

- Number of items: 654 items
- Choice rows: 1962 rows (654 items * 3 choices)
- Number of people: 182 people
- Ticket gate i=See previous page
- User id: n
- Trip purpose P (=110 return home, 200/210 entertainment, 300/310 work, other)

提案手法：乗車改札の特定

- feeder データから、交通手段コード（ModeCode）が「徒歩（500）」から「鉄道（100または101）」に変化する切り替わりレコードを抽出し、そのタイムスタンプを $T_{onboard}$ とする
- 各歩行者の、 $t = T_{onboard} - 20\ \mathrm{min}$ または追跡が始まった時間のうち早い方を(仮)出発地として定義
- $T_{onboard} - 5 \leqq t \leqq T_{onboard}$に対応する点群$\mathcal{L}_n = \{(lat_k, lon_k) \mid k = 1,2,\dots,K\}$を抽出，時間をt'=-5〜0として再定義
- 点群内の各測位点 k と、4つの改札代表点$i \in \{\mathrm{north}, \mathrm{central}, \mathrm{south}\}$との距離$d(k,i)$を計算
- $\max(-70t' + 10, 80)$より小さい$d(k,i)$を全て抽出
- 抽出された$d(k,i)$がただ一つであれば、改札iを選択ラベル Y_n として確定
- 抽出された$d(k,i)$が複数ある場合、最小の$d(k,i)$について、改札iを選択ラベル Y_n として確定

Proposed method: Identification of boarding gates

- From the feeder data, extract the transition record where the mode of transport code (ModeCode) changes from "Walking (500)" to "Rail (100 or 101)," and designate its timestamp as $T_{onboard}$.
- For each pedestrian, define the (provisional) starting point as either $t = T_{onboard} - 20\ \mathrm{min}$ or the time tracking began, whichever is earlier.
- Extract the point set $\mathcal{L}_n = \{(lat_k, lon_k) \mid k = 1,2,\ldots,K\}$ corresponding to $T_{onboard} - 5 \leqq t \leqq T_{onboard}$, and redefine the time range as t'=-5 to 0.
- Calculate the distance $d(k,i)$ between each positioning point k in the point cloud and the four ticket gate representative points i ∈ $\{\mathrm{north}, \mathrm{central}, \mathrm{south}\}$.
- Extract all $d(k,i)$ smaller than $\max(-70\mathrm{t'} + 10, 80)$.
- If the extracted $d(k,i)$is only one, ticket gate i is confirmed as the selected label Y_n.
- If there are multiple extracted $d(k,i)$, for the smallest $d(k,i)$, determine ticket gate i as the selected label Y_n.

提案手法：移動時間にかかる時間の算定

出発地$\left(lat_{dest,n}, lon_{dest,n}\right)$から各改札の代表の距離・歩行時間の測定

地球を平均半径$R = 6{,}371{,}008.8\ m$の球として扱う．緯度をϕ，経度をλとすると，ラジアンに変換して

$$a = \sin^2 \frac{\phi_2 - \phi_1}{2} + \cos \phi 1 \cos \phi 2 \sin^2 \frac{\lambda_2 - \lambda_1}{2}$$

$$D_{ni} = 2R \arcsin \sqrt{a}$$

とする．時間変数は

$$T_{ni} = \frac{D_{ni}}{70}$$

とする．

Proposed Method: Estimation of Travel Time

Measurement of distance and walking time from the origin $(l, at_{dest,n} lon_{dest,n})$to each ticket gate
The Earth is treated as a sphere with a mean radius of

$$R = 6{,}371{,}008.8\ \mathrm{m}$$

Let latitude be $\phi$and longitude be λ. After converting them to radians:

$$a = \sin^2 \frac{\phi_2 - \phi_1}{2} + \cos \phi 1 \cos \phi 2 \sin^2 \frac{\lambda_2 - \lambda_1}{2}$$

$$D_{ni} = 2R \arcsin \sqrt{a}$$

The travel-time variable is then defined as:

$$T_{ni} = \frac{D_{ni}}{70}$$

モデル / Model

MNL-based

BASE

$$V_{n,i} = ASC_i + \beta_{walk} T_{ni}$$

Model-1

$$V_{n,i} = ASC_i + \beta_{walk} T_{ni} + \beta_{cowork} P_{np} Cowork_{ni}$$

Model-2

$$V_{n,i} = ASC_i + \beta_{walk} T_{ni} + \beta_{cowork} P_{np} Cowork_{ni} + \beta_Q Q_{ni}$$

Model-3

$$V_{n,i} = ASC_i + \beta_{walk} T_{ni} + \beta_{cowork} P_{np} Cowork_{ni} + \beta_Q Q_{ni} + \sum_k \beta_k q_{nki}$$

各文字の説明

各文字の説明

- ASC_i ：選択肢固有定数
- T_{ni} ：User nが改札 i までにかかる移動時間
- P_{np} ：User nが目的 p までにかかる移動時間
- $Cowork_i$: Cowork施設jの改札 i からのHaversine距離を d_{ij}とし，距離減衰アクセシビリティを $\log\left(1+\sum_j \exp\left(-d_{ij}/300m\right)\right)$ で表したもの
- Q_{ni} ：Hot Pepperに記載されている渋谷周辺1000店舗について，店舗 j に関する信頼スコアを$confidence_j$として，店舗の重みを$w_{nij} = confidence_j \times exp\left(-\Delta_{nij}/300m\right)$ としたとき， $Q_{ni} = log\left(1+\Sigma_{j:\Delta_{nij}\leq 100m} w_{nij}\right)$
- q_{nik} ：各店舗 jをLLMにより、店舗紹介・業態・設備等の文章から、目的に直接依存しない4軸 ‘experience’、’social’、’quiet_work’、’night_activity’ に0〜1で採点する.

$$q_{nik} = \Sigma_{j:\Delta_{nij}\leq 100m} w_{nij} \times score_j k / \Sigma_{j:\Delta_n ij\leq 100m} w_{nij}$$

Explanation of Variables

ASCi: Alternative-specific constant
T_{ni}: Travel time for user $n$to reach ticket gate i
P_{np}: Travel time for user $n$to reach destination p
$Cowork_i$: Distance-decay accessibility to coworking facilities, where $d_{ij}$is the Haversine distance from ticket gate $i$to coworking facility

$$Cowork_i = \log\left(1 + \sum_j \exp(-d_{ij}/300m)\right)$$

Qni: For approximately 1,000 establishments around Shibuya listed on Hot Pepper, let $confidence_j$denote the reliability score of establishment j, and define its weight as wnij=confidencej × exp(−Δnij/300m)

$$Q_{ni} = \log\left(1 + \sum_{j:\Delta_{nij} \leq 100m} w_{nij}\right)$$

qnik: Each establishment $j$is scored by an LLM on four dimensions that do not directly depend on the trip purpose—**experience**, **social**, **quiet_work**, and **night_activity**—on a scale from 0 to 1, based on descriptions of the establishment, business type, facilities, etc.

$$q_{nik} = \frac{\sum_{j:\Delta_{nij} \leq 100m} w_{nij} \times score_{jk}}{\sum_{j:\Delta_{nij} \leq 100m} w_{nij}}$$

各文字の説明

各文字の説明

- 使用LLMについてホットペッパーグルメ Webサービスから取得したデータをGPT5.6 Lunaに入れてスコア化

- `experience`: 0＝日常的・短時間・単純な立ち寄り、1＝わざわざ訪れる・長居・特別感・目的地性。
- `social`: 0＝一人・少人数・個人利用中心、1＝宴会・友人・大人数・交流中心。
- `quiet_work`: 0＝賑やか・騒がしい・作業に不向き、1＝静か・会話・読書・作業・打合せに向く。
- `night_activity`: 0＝朝昼・日常的食事・喫茶中心、1＝酒・バー・二次会・深夜滞在・夜景・ナイトライフ中心。
-

Explanation of Variables

- **LLM used**: Data obtained from the Hot Pepper Gourmet Web Service were input into **GPT-5.6 Luna** and scored.
- **experience**:
  0 = everyday / short stay / casual stop
  1 = worth visiting specifically / long stay / special experience / destination-oriented
- **social**:
  0 = solo / small group / individual use
  1 = parties / friends / large groups / interaction-oriented
- **quiet_work**:
  0 = lively / noisy / unsuitable for work
  1 = quiet / suitable for conversation, reading, working, or meetings
- **night_activity**:
  0 = daytime / everyday meals / café-oriented
  1 = alcohol / bars / after-parties / late-night stays / night views / nightlife-oriented

結果

Model	N	McFadden rho	指標2	指標3	指標4
M0_base_t_asc	517	0.2900	0.3552	66.3%	72.3%
M1_prime_all_facilities	517	0.2951	0.3575	64.2%	72.3%
M2_prime_all_facilities_quantity	517	0.3015	0.3620	64.2%	67.9%
M3_prime_all_facilities_quantity_quality_mean	517	0.3110	0.3854	68.5%	70.1%

モデルにこの順番に変数を加えても，モデルの性能は改善した．

Results

Model	N	McFadden rho	指標2	指標3	指標4
M0_base_t_asc	517	0.2900	0.3552	66.3%	72.3%
M1_prime_all_facilities	517	0.2951	0.3575	64.2%	72.3%
M2_prime_all_facilities_quantity	517	0.3015	0.3620	64.2%	67.9%
M3_prime_all_facilities_quantity_quality_mean	517	0.3110	0.3854	68.5%	70.1%

Even when the variables were added to the model in this order, the model's performance improved.

結果

カラオケとfitnessは有意ではない

Feature	Coefficient	Robust SE	p-value	95% CI
beta_walk	-0.4074	0.0598	0.0000	[-0.5247, -0.2900]
asc__jr_hachiko	0.1165	0.1898	0.5392	[-0.2554, 0.4885]
asc__jr_shinminami	-1.9977	0.2820	0.0000	[-2.5504, -1.4451]
leisure_x_karaoke_access	-0.4359	0.7803	0.5764	[-1.9654, 1.0935]
leisure_x_fitness_access	-0.8594	1.1131	0.4401	[-3.0411, 1.3222]
work_x_cowork_access	3.4001	1.7873	0.0571	[-0.1029, 6.9032]

Results

Karaoke and fitness are not statistically significant.

Feature	Coefficient	Robust SE	p-value	95% CI
beta_walk	-0.4074	0.0598	0.0000	[-0.5247, -0.2900]
asc__jr_hachiko	0.1165	0.1898	0.5392	[-0.2554, 0.4885]
asc__jr_shinminami	-1.9977	0.2820	0.0000	[-2.5504, -1.4451]
leisure_x_karaoke_access	-0.4359	0.7803	0.5764	[-1.9654, 1.0935]
leisure_x_fitness_access	-0.8594	1.1131	0.4401	[-3.0411, 1.3222]
work_x_cowork_access	3.4001	1.7873	0.0571	[-0.1029, 6.9032]

結果

飲食店の量のデータに比べて質を表すものの影響は弱い.

Feature	Coefficient	Robust SE	p-value	95% CI
beta_walk	-0.2160	0.0481	0.0000	[-0.3102, -0.1218]
asc__jr_hachiko	0.3677	0.2152	0.0875	[-0.0540, 0.7894]
asc__jr_shinminami	-2.1340	0.2911	0.0000	[-2.7047, -1.5634]
work_x_cowork_access	4.3885	1.7710	0.0132	[0.9172, 7.8597]
beta_Q	-1.4438	0.4618	0.0018	[-2.3489, -0.5387]
beta_experience	15.5905	12.4332	0.2099	[-8.7785, 39.9595]
beta_social	11.2058	11.1861	0.3165	[-10.7189, 33.1306]
beta_quiet_work	-29.1762	14.7842	0.0484	[-58.1533, -0.1991]
beta_night_activity	-20.6048	7.9272	0.0093	[-36.1422, [illegible]674]

Results

Compared with measures of restaurant quantity, indicators representing restaurant quality have a weaker effect.

Feature	Coefficient	Robust SE	p-value	95% CI
beta_walk	-0.2160	0.0481	0.0000	[-0.3102, -0.1218]
asc__jr_hachiko	0.3677	0.2152	0.0875	[-0.0540, 0.7894]
asc__jr_shinminami	-2.1340	0.2911	0.0000	[-2.7047, -1.5634]
work_x_cowork_access	4.3885	1.7710	0.0132	[0.9172, 7.8597]
beta_Q	-1.4438	0.4618	0.0018	[-2.3489, -0.5387]
beta_experience	15.5905	12.4332	0.2099	[-8.7785, 39.9595]
beta_social	11.2058	11.1861	0.3165	[-10.7189, 33.1306]
beta_quiet_work	-29.1762	14.7842	0.0484	[-58.1533, -0.1991]
beta_night_activity	-20.6048	7.9272	0.0093	[-36.1422, -5.0674]

結果

新南への便益	時間短縮相当	新南選択率	0円からの増分
0円	0.0分	4.488%	—
20円	0.5分	5.035%	+0.547pt
40円	1.0分	5.640%	+1.152pt
60円	1.5分	6.307%	+1.819pt
80円	2.0分	7.041%	+2.553pt
100円	2.5分	7.845%	+3.357pt

※VOTは国土交通省の費用便益マニュアルを参照してVOT=40とした

Results

Profit to New_South_Exit (yen)	How much time Can be saved(min)	Percentage of Choosing New_South_Exit	Percentage change from 0 yen
0	0.0	4.488%	—
20	0.5	5.035%	+0.547pt
40	1.0	5.640%	+1.152pt
60	1.5	6.307%	+1.819pt
80	2.0	7.041%	+2.553pt
100	2.5	7.845%	+3.357pt

※VOT=40, based on Japanese Governmental Report

結果

飲食店のデータだけだが，解釈不能ではない

改札群	Choice sets	Experience 平均	SD	social 平均	SD	quiet_work 平均	SD	night_activity 平均	SD
JRハチ公	654	0.5377	0.0168	0.5853	0.0237	0.3056	0.0214	0.6001	0.0549
JR中央・南	654	0.5481	0.0261	0.5671	0.0374	0.3169	0.0344	0.5829	0.0713
JR新南	654	0.5429	0.0146	0.5618	0.0273	0.3198	0.0253	0.5701	0.0643

Result

Although the data are limited to restaurants, they are still interpretable.

改札群	Choice sets	Experience avg	SD	social avg	SD	quiet_work avg	SD	night_activity avg	SD
JR_Hachiko	654	0.5377	0.0168	0.5853	0.0237	0.3056	0.0214	0.6001	0.0549
JR_Central, South	654	0.5481	0.0261	0.5671	0.0374	0.3169	0.0344	0.5829	0.0713
JR_newsouth	654	0.5429	0.0146	0.5618	0.0273	0.3198	0.0253	0.5701	0.0643

結論 / Conclusion

- 金銭インセンティブ（キャッシュバック）は班の直感に沿う結果となった
- Karaokeとfitnessは改札口選択への影響がない．すなわち，どの改札口から電車に乗るかへの影響はない．
- Co-workingspaceのような，有意な変数を発見することができた．
- 飲食店を対象に，施設の量と種類を選択モデルに組み込むという挑戦をし，施設の量についてはうまく組み込めたが，質については有意な結果は得られなかった．
飲食店以外のデータや POIデータへの接続などの拡張が重要だと感じた．

- Confirmed that monetary incentives (cashback) produced results consistent with our group’s intuition.
- Found that karaoke and fitness facilities had no significant effect on ticket gate choice.
- Identified significant variables, including the presence of co-working spaces.
- Incorporated the quantity and types of restaurant facilities into the choice model, successfully capturing the effect of facility quantity but not obtaining significant results for facility quality.
- Identified the need to expand the analysis to non-restaurant facilities and integrate POI data.