代表交通手段選択モデルを用いた CO_2 排出量と交通利便性の関係の可視化

Visualizing the relationship
between the amount of CO_2 emission and the usability of transportation
by using representative transportation mode choice model

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1. Backgrounds and Purpose

- 近年，CO_2排出量の削減が世界的に重要な課題となっている.
- These days, **reducing the amount of CO_2 emissions** is one of the most important problems all over the world.

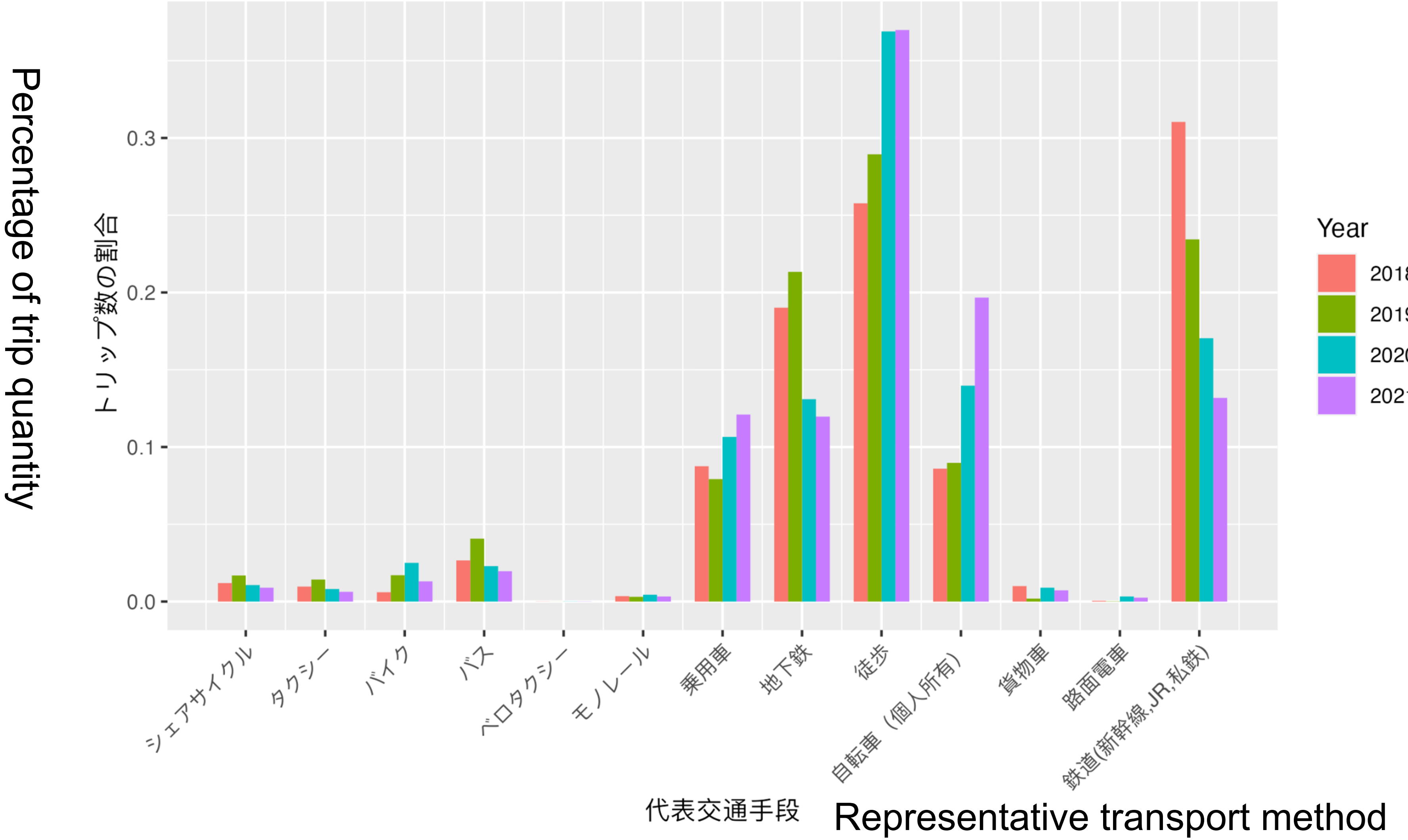
- 交通の利便性をできるだけ保ちながらCO_2排出量を減らしたい.
- We want to **reduce the amount of CO_2 emission** from transportation, **retaining the usability of transportation** as much as possible.

2. Summary of data used for estimation

- 基礎集計にはtoyosu2018-2021 PPデータ全体を使用しました.
- パラメータ推定にはtoyosu2021 PPデータのみを使用しました
  .

- Summarize toyosu2018-2021 PP data sets
- However, use only toyosu2021 PP data sets for estimation

2. Summary of data used for estimation



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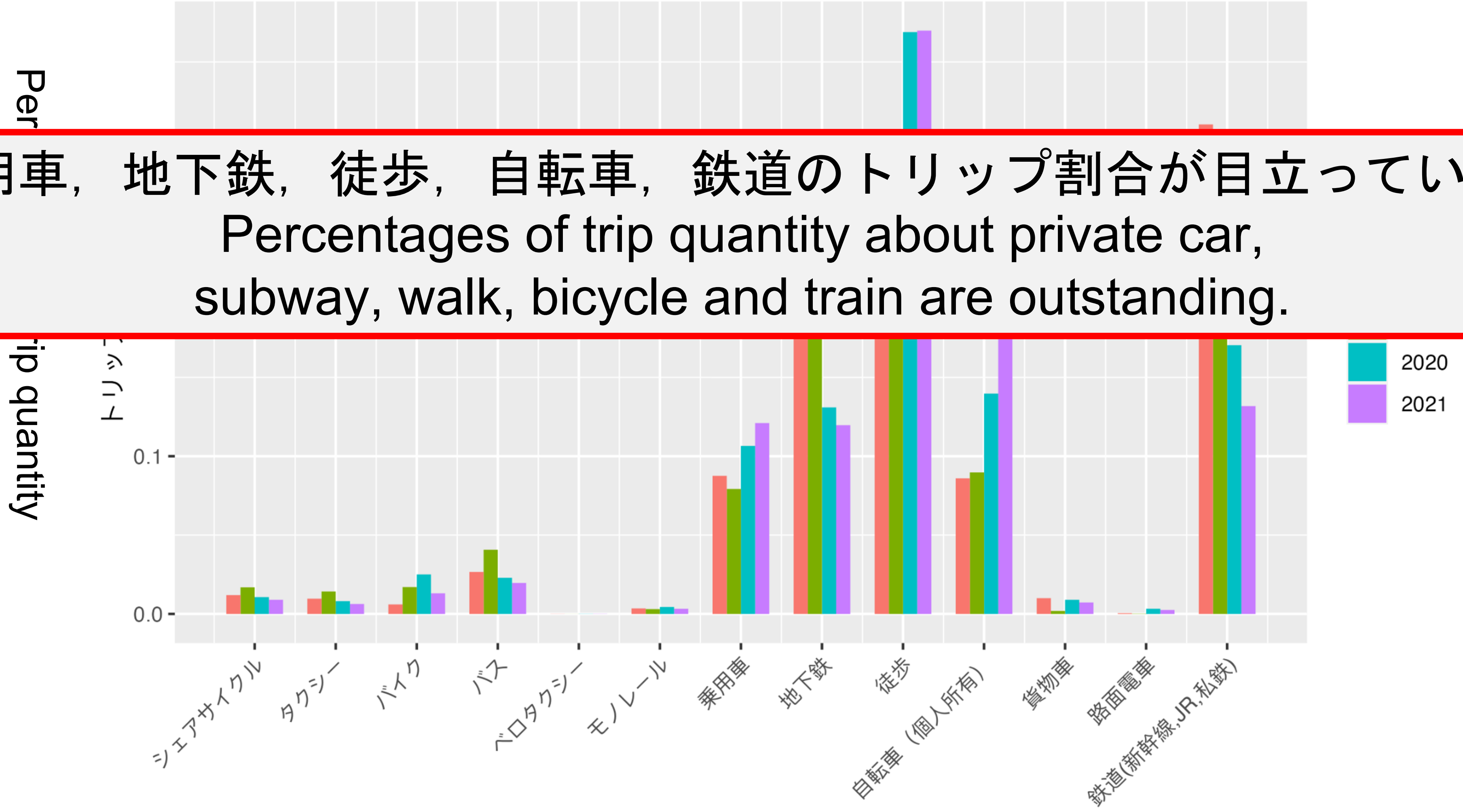


乗用車，地下鉄，徒歩，自転車，鉄道のトリップ割合が目立っている．
Percentages of trip quantity about private car,
subway, walk, bicycle and train are outstanding.

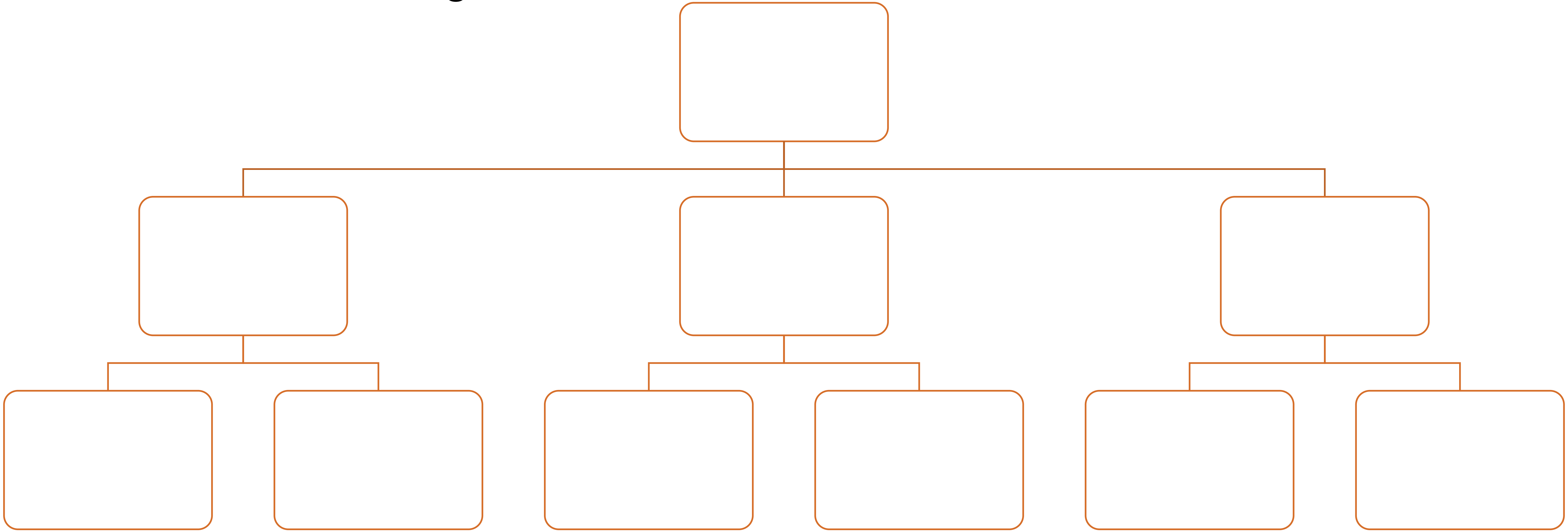
2. Summary of data used for estimation

- トリップ割合が目立つ乗用車，徒歩，自転車，鉄道と説明変数の観測値が扱いやすそうなタクシーとバスを代表交通手段選択モデルの選択肢とする.

- In representative transportation mode choice model, choices include car, walk, bicycle, and train whose percentages of trip quantity are outstanding, and taxi and bus whose observation values of explanatory variables we can easily know.

3. Model

- Use Nested Logit Model



3. Model

確定項の定式化　The deterministic term

$$V_{taxi} = t_1 \times x_{taxi}^{time} + d_1 \times x_{taxi}^{distance} + f_1 \times x_{taxi}^{fare} + b_{taxi}$$

$$V_{car} = t_1 \times x_{car}^{time} + d_1 \times x_{car}^{distance} + b_{car}$$

$$V_{train} = t_1 \times x_{train}^{ridingtime} + t_2 \times x_{train}^{accesstime} + t_3 \times x_{train}^{egresstime}$$

$$+ d_1 \times x_{train}^{ridingdistance} + d_2 \times x_{train}^{accessdistance} + d_3 \times x_{train}^{egressdistance}$$

$$+ f_1 \times x_{train}^{fare} + b_{train}$$

3. Model

確定項の定式化　The deterministic term

$$V_{bus} = t_1 \times x_{bus}^{ridingtime} + t_2 \times x_{bus}^{accesstime} + t_3 \times x_{bus}^{egresstime}$$
$$+d_1 \times x_{bus}^{ridingdistance} + d_2 \times x_{bus}^{accessdistance} + d_3 \times x_{bus}^{egressdistance}$$
$$+f_1 \times x_{bus}^{fare} + b_{bus}$$

$$V_{bicycle} = t_1 \times x_{bicycle}^{time} + d_1 \times x_{bicycle}^{distance} + b_{bicycle}$$

$$V_{walk} = t_1 \times x_{walk}^{time} + d_1 \times x_{walk}^{distance}$$

4. Estimation results

Nested Logit Model

Constant term

	Taxi	Railway	Car	Bus	Bicycle
Estimated Value	0.53449984	-9.84188189	-1.05405342	-2.79201731	-11.66508406
t-value	2.353926	-0.4260685	-4.029681	-0.1058483	-0.4630774

4. Estimation results　Nested Logit Model

Parameter

	t1 (riding time)	t2 (access time)	t3 (egress time)
Estimated Value	49.79167121	-0.18426781	-0.22686972
t-value	8.331116	-4.084440×10^{-4}	-4.383971×10^{-4}

	d1 (riding distance)	d2 (access distance)	d3 (egress distance)
Estimated Value	-0.21002732	-0.90798215	-1.11395593
t-value	-10.85693	-9.660530×10^{-3}	-1.033238×10^{-2}

	f1 (fare)
Estimated Value	0.03255534
t-value	6.054657

5. Visualizing

- If we can estimate parameters correctly, we can calculate choice probability of representative transportation mode.

- Using the probabilities, we can evaluate the expected value of the amount of CO_2 emissions per person and the expected value of the usability of transportation.

5. Visualizing

- the expected value of the amount of CO_2 emissions per person

$$\sum_{mode} CO2\ basic\ unit\left[\frac{g}{km \cdot person}\right] \times distance \times Probability$$

- the expected value of the usability of transportation per person.

$$\sum_{mode} usability \times distance \times Probability$$

5. Visualizing

Want to reduce!

Want to retain!

- the expected value of the amount of CO_2 emissions per person

$$\sum_{mode} CO2\ basic\ unit\left(\frac{g}{km \cdot person}\right) \times distance \times Probability$$

- the expected value of the usability of transportation per person.

$$\sum_{mode} usability \times distance \times Probability$$

5. Visualizing

Want to reduce!

Want to retain!

- the expected value of the amount of CO_2 emissions per person

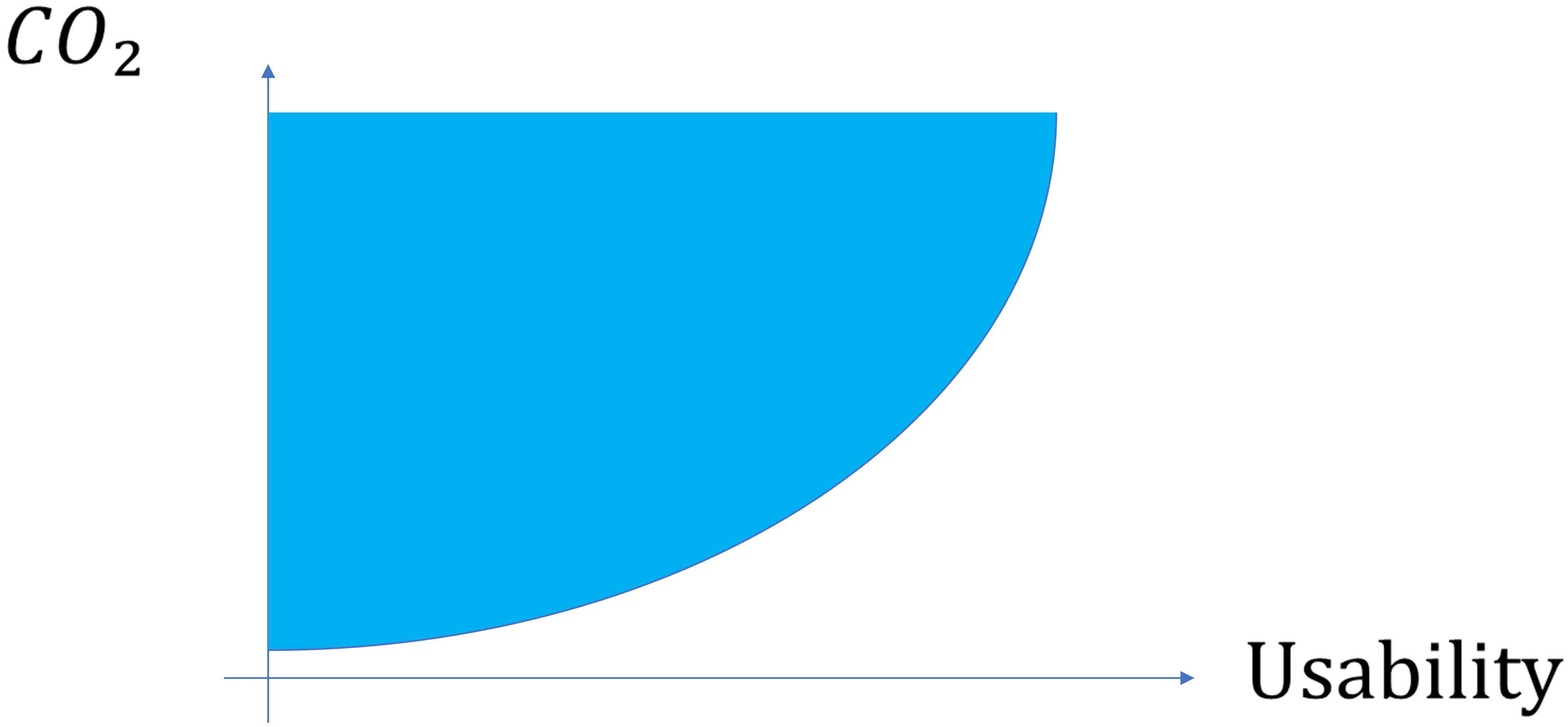
$$\sum_{mode} CO2\ basic\ unit\left(\frac{g}{km \cdot person}\right) \times distance \times Probability$$

contradict each other!

- the expected value of the usability of transportation per person.

$$\sum_{mode} usability \times distance \times Probability$$

5. Visualizing probably…？



Reference

- 大山雄己, & 羽藤英二. (2017). 多目的最適化に基づく歩行者の活動ネットワークデザイン. 都市計画論文集, 52(3), 810-817.
- https://www.mlit.go.jp/sogoseisaku/environment/sosei_environment_tk_000007.html
- https://www.mlit.go.jp/singikai/koutusin/rikujou/jidosha/bus/06/images/04.pdf
- https://www.ktr.mlit.go.jp/ktr_content/content/000783467.pdf
- https://www.mlit.go.jp/hakusyo/transport/heisei05/2/52-5-1.HTM

Reference

- 大矢 周平, 中村 一樹, 板倉 颯, 交通手段の組み合わせを考慮した移動の質の評価, 土木学会論文集D3（土木計画学）, 2020, 76 巻, 5 号, p. I_1147-I_1153.
- https://www3.nhk.or.jp/news/html/20221011/k10013854961000.html
- http://www.kojintaxi-tokyo.or.jp/cus/fares_table.html
- http://library.jsce.or.jp/jsce/open/00039/201206_no45/pdf/294.pdf
- http://library.jsce.or.jp/jsce/open/00039/201105_no43/pdf/375.pdf

Appendix

● タクシー利用のデータ計算法　How to calculate taxi data

- 所要時間taxiと距離taxiは，所要時間carと距離taxiを流用
- We use Time of car and Distance of car as Time of taxi and Distance of taxi.

Appendix

- タクシー利用のデータ計算法　How to calculate taxi data
- 費用taxiは，距離taxiを以下の関数で換算
- We calculate Fare of taxi by the below function of Distance of taxi.

If Distance of taxi ≤ 1.096km:

$$x_{taxi}^{fare} = 420 \text{ (JPY)}$$

Else:

$$x_{taxi}^{fare} = 420 + 80 \times \left(x_{taxi}^{Distance} - 1.096\right) \div 0.233 \text{ (JPY)}$$

Appendix

- 自転車利用のデータ計算法　How to calculate bicycle data
- 所要時間bicycleは，所要時間walkを以下の関数で換算
- We calculate Time of bicycle by the below function of Distance of walk.

$$x_{bicycle}^{time} = \frac{v_{walk}}{v_{bicycle}} \times x_{walk}^{time} = \frac{3.6\ (km/h)}{9.6\ (km/h)} \times x_{walk}^{time}$$