Bicycle Route choice model in Matsuyama city

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Behavior in Networks Studies Unit

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1. Background
2. Basic analysis
3. Model structure
4. Simulation & Estimation results
5. Suggestion; How we struggled with RL model

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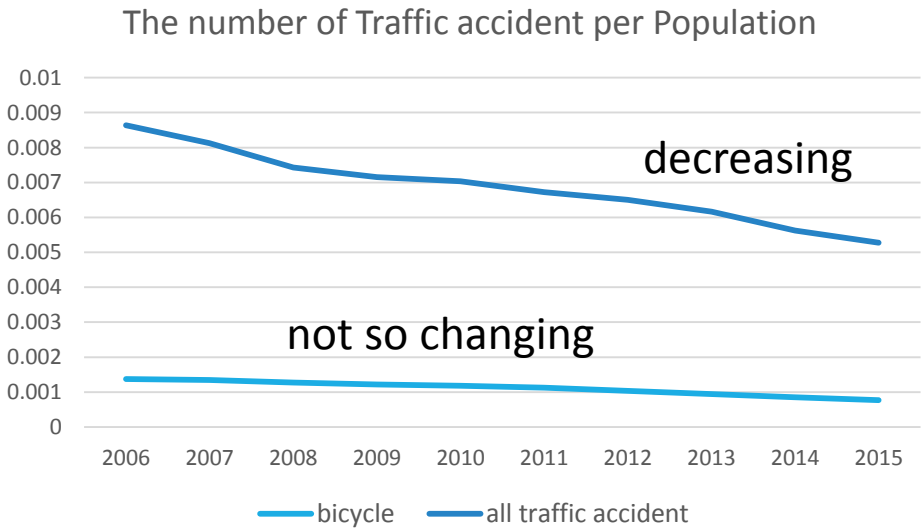
Necessity of Bicycle behavior analysis

1. For the environment of the earth
2. For both tourist and local people
3. Not only for bicycle rider, but also for walker & car driver
4. In order to decrease the number of traffic accident effectively, we have to know bicycle behavior



e-Stat http://www.e-stat.go.jp/SG1/estat/eStatTopPortal.do

Bicycle policy in Matsuyama city

1999

Matsuyama city total policy about using Bicycle

松山市自転車等利用総合計画

-harmony with people and city

2011

NEW Matsuyama city total policy about using Bicycle

新松山市自転車等利用総合計画(松山市自転車マスタープラン)

Start from 2017/3/27

https://www.pref.ehime.jp/h40900/matsu-ima_blueline.html

[Bicycle parking]

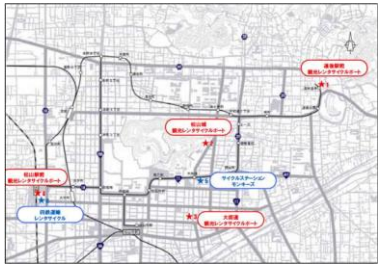
- Hanazono-town street parking
- Matsuyama city office 4th annex parking

[Bicycle road]

Reduce Width of roadway &
give width to sidewalk

Bus priority lane and sub lane

[Rental bicycle]



平成 21 年度時点，
松山市ｺﾐｭﾆﾃｨｻｲｸﾙ実証実験報告書
（今回使用する松山PPは平成19年度）

➢**One of Bicycle roles defined by city:**

a means of transportation in the central aria

Bicycle trips in Matsuyama city

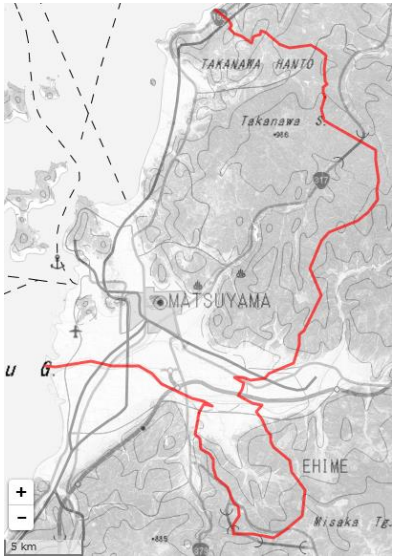
- All of the trips including bicycle →1471

  -only bicycle(does not change transportation mode)→1305

  -not “only bicycle”→166

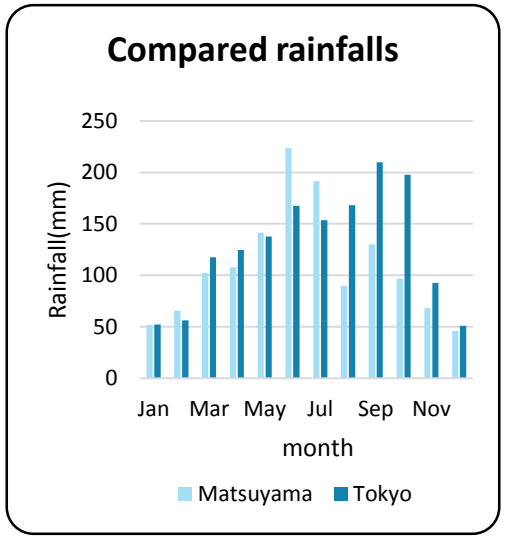
Why so many people use bicycle in Matsuyama city

➢flat in the central area of the city



Kokudo-Chiriin map

➢small rainfall and many sunny days



Annual rainfall
Tokyo : 1528.8 mm,
Matsuyama : 1314.9 mm

https://www.time-j.net/

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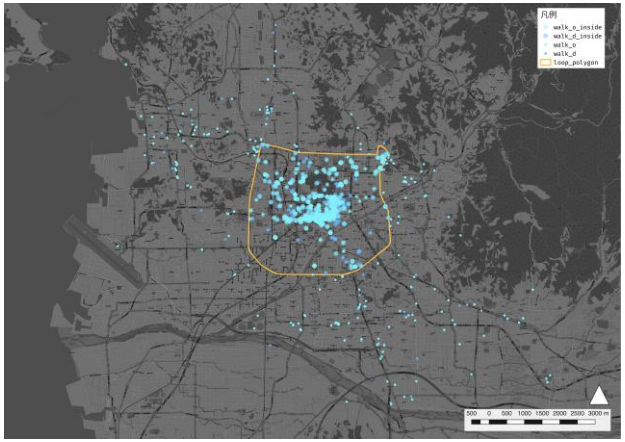
Transportation mode and OD

Matsuyama PP

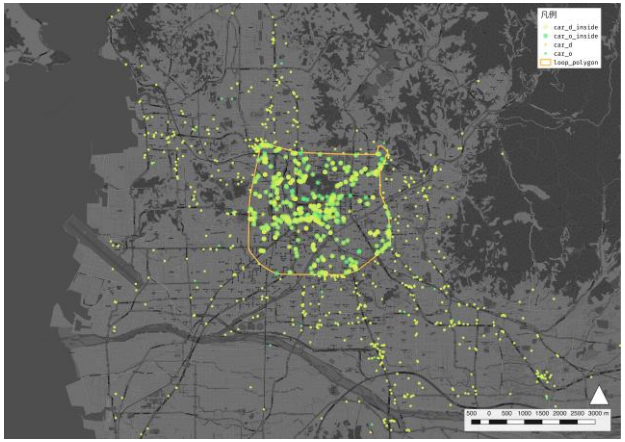
Many trips have both O and D in the Matsuyama loop line, especially in the mode “walk” and “bicycle”.

walk



bicycle

car



the Matsuyama loop line and DID

The Matsuyama loop line

- Matsuyama-city, Iwasaki-town 2⇔Hirata-town
- About 12.9km, load designed in urban planning

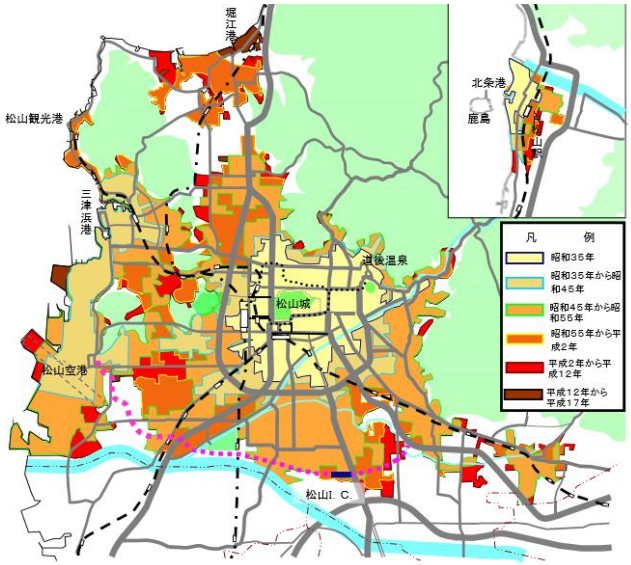
Densely Inhabited District in Matsuyama city

in the inner side of the loop line,

- Matsuyama Castle →area around it developed
- Dogo Hotspring
- “Ohennro-miti” road (religious meaning)

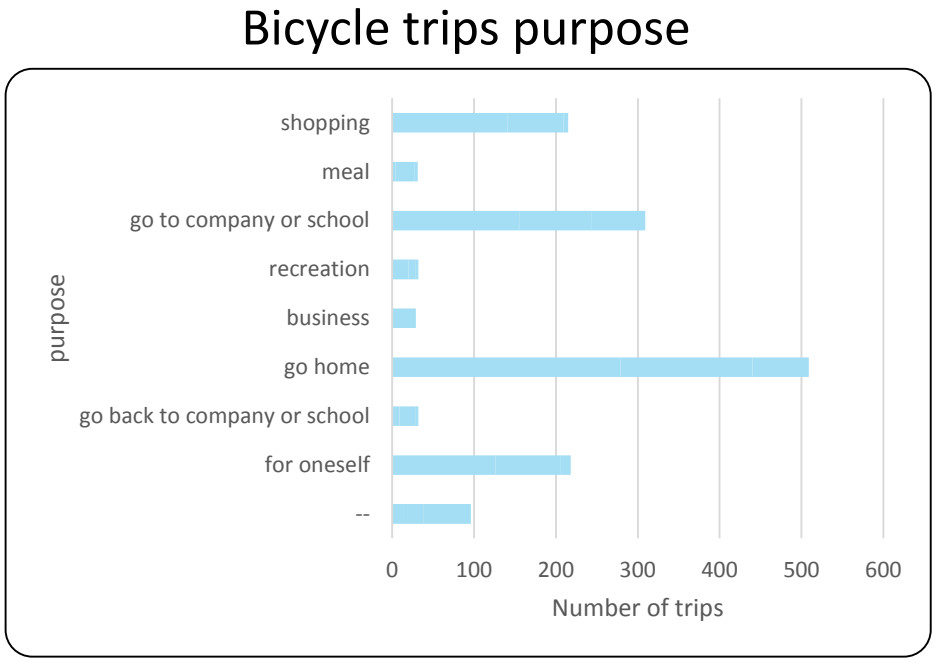
→area around it developed

→has been DID for long



http://www.mlit.go.jp/seisakutokatsu/soukou/soukou-magazine/1001matsuyama-ehime.pdf

Bicycle: trip purpose

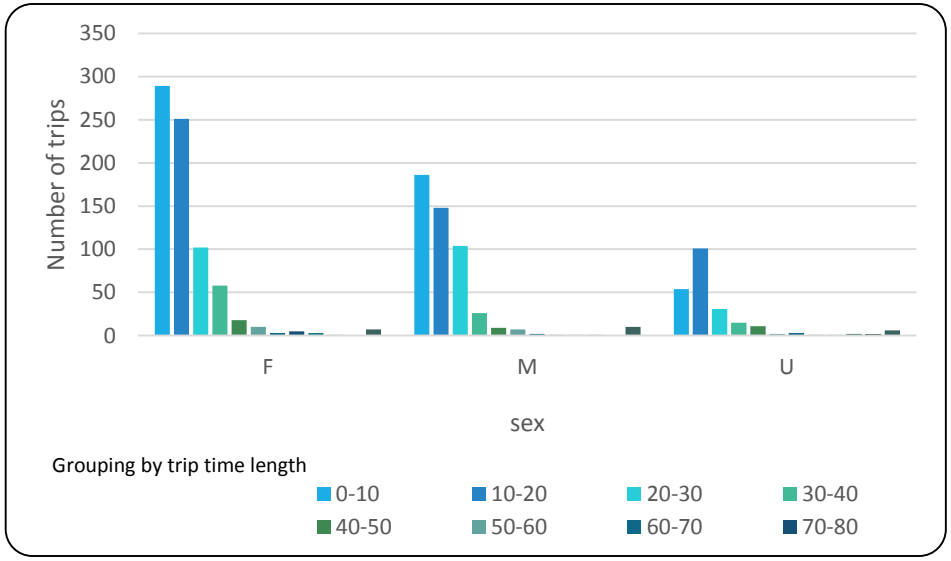


Matsuyama PP
All of the trips including “bicycle”→1471

- Many usual purpose trips, especially purpose “go home” and “go to the company or school”
- Next “shopping” and “for oneself” trips are also big in number

Bicycle: difference in sex

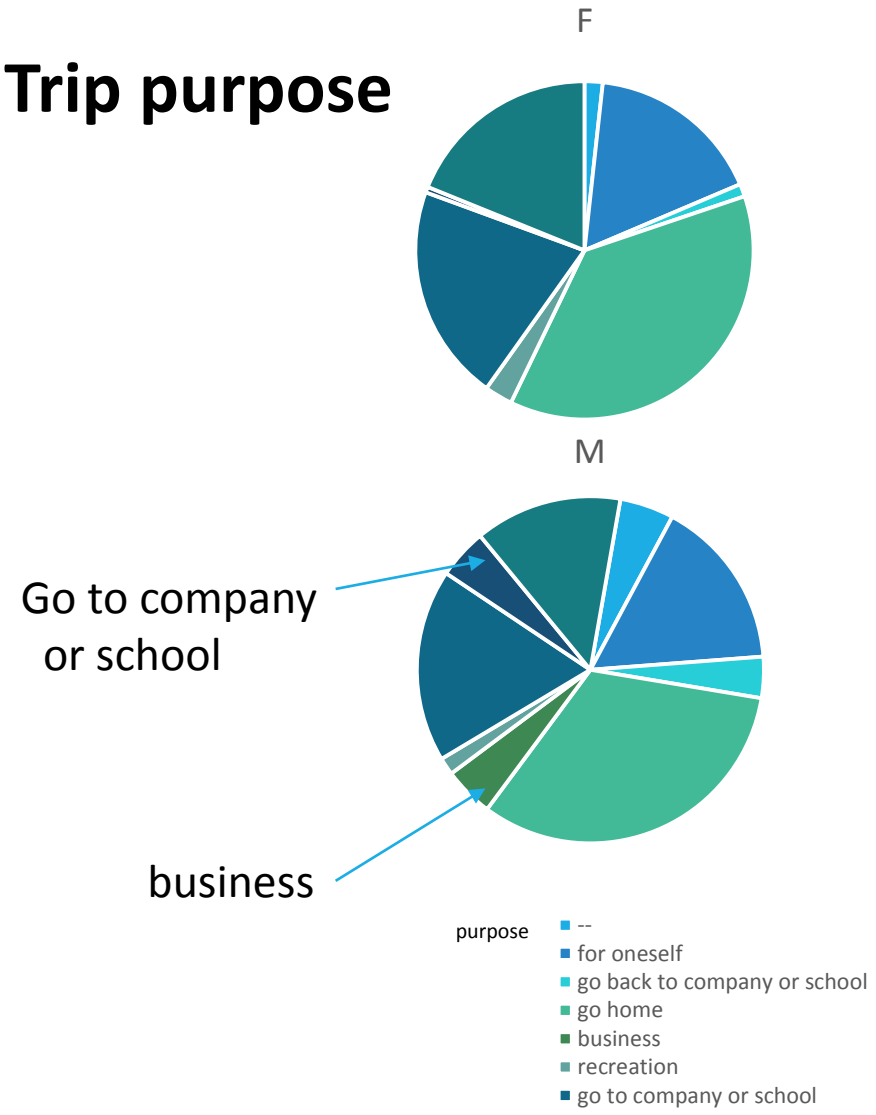
Trip time length



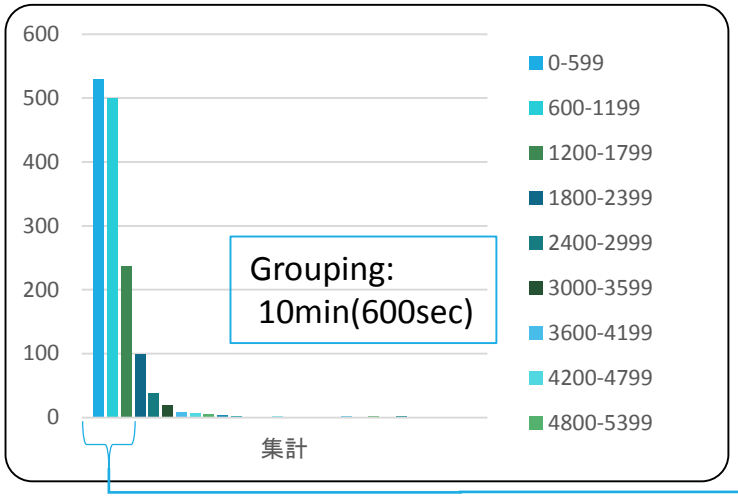
Matsuyama PP.
Female trip→747
Male trip→494
Unknown trip→229

Male use bicycle more frequently for 20-30 min trip than Female?

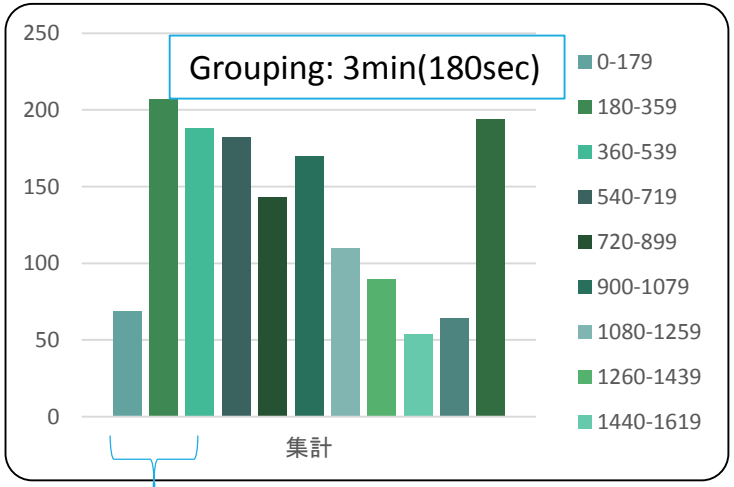
Trip purpose



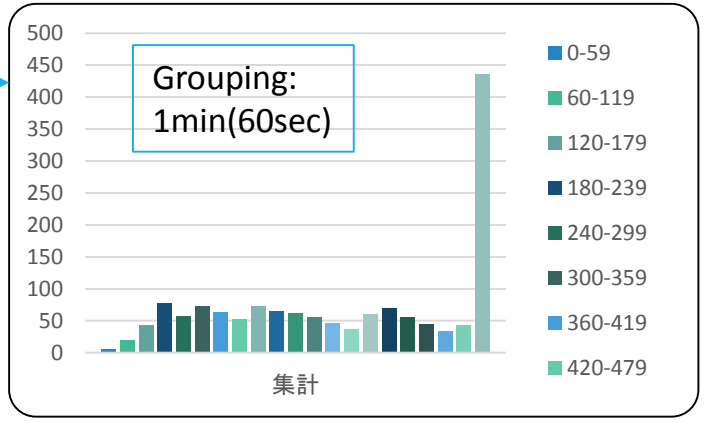
Bicycle: trip time length



In every graph
vertical: number of trips
horizontal: grouping by trip time length



Concentration on
less than about 30min: 1800sec?



Maybe people don't use bicycle
when the trip time length is less than 3min?

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Over view

Purpose: Bicycle Route choice model

Comparison of the models

① Pre-trip type
k shortest path search + MNL model

② En-route type
RL(generalized recursive logit) model

Consideration on data size

The whole Matsuyama PP Bicycle trip data ： too big to estimate

Data Divided into 4 area ： too biased and link alternative

Parameter Estimation of RL(recursive logit) model

Simple simulation and decision explanatory variables

Purpose: Bicycle Route choice model

Route choice Method

1. Pre-trip type

   Ex.) k shortest path search + MNL model

2. En-route type

   Ex.) RL(recursive logit) model

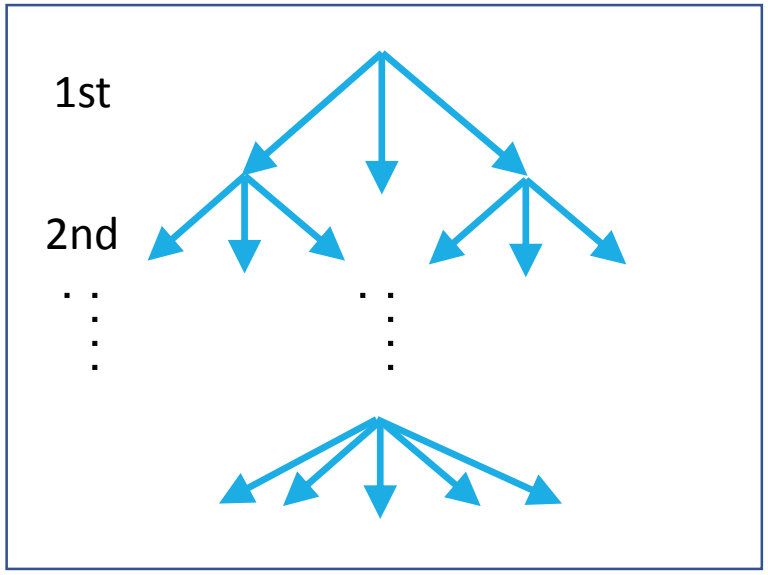


Fig.1 k shortest path search

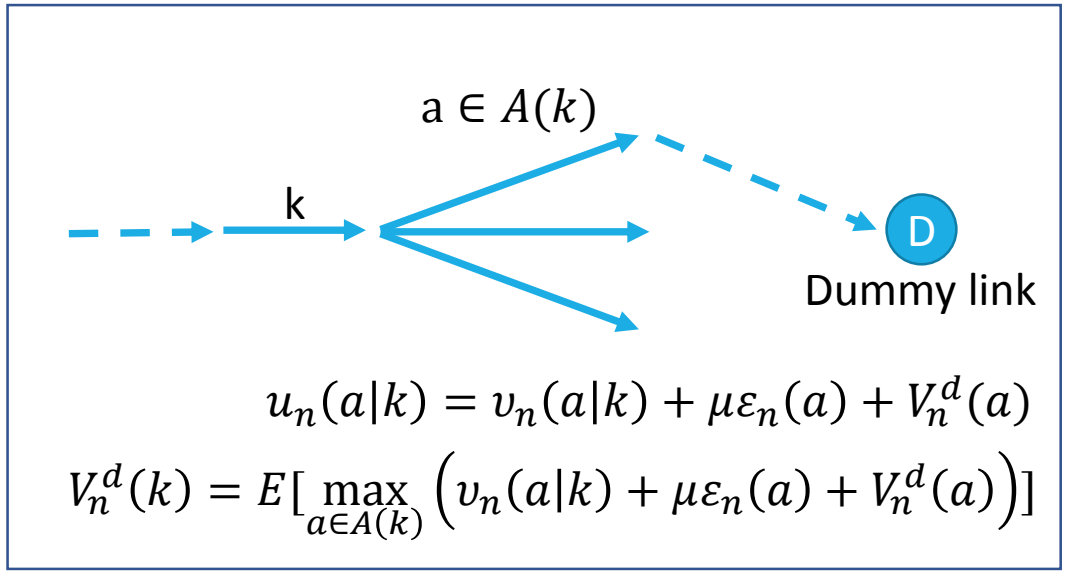


Fig.2 RL(recursive logit) model

① k shortest path search Comparison of the models

137	pathID	Origin	Destinatic	Cost	Link											
138	123	55700558	55000629	196	5008918	5008909	5008915									
139	124	55700558	55000629	238	5008918	5008911	5011181	5008914								
140	125	55700558	55000629	387	5011199	5018102	5018099	5018105	5011206	5008920						
141	126	55700558	55000629	422	5008918	5008911	5011160	5011154	5011155	5008914						
142	127	55700558	55000629	580	5008918	5008911	5011181	5007936	5007454	5007455	5007457					
143	128	55700558	55000629	581	5008918	5008911	5011160	5011132	5011129	5011135	5011155	5008914				
144	129	55700558	55000629	588	5011199	5018102	5016106	5016101	5007943	5008722	5008703	5008719	5008909	5008915		
145	130	55700558	55000629	589	5011199	5018102	5018103	5019837	5018108	5018105	5011206	5008920				
146	131	55700558	55000629	630	5011199	5018102	5016106	5016101	5007943	5008722	5008703	5008719	5008911	5011181	5008914	
147	132	55700558	55000629	655	5011199	5018102	5016106	5016101	5007943	5008722	5008705	5009843	5011181	5008914		

Choice of which cost is over **15** times longer than shortest cannot be choose

…too big cost to choose & small number of routes

Problem is…

- On each node, **the number of links is few** in Matsuyama.

→if you make the alternatives of enough number, the length of alternative trip is too long to select(about 15 times longer)

∵O and D of the each trip are too near in bicycle trip in the central area.

- People **cannot detect all of the route alternatives** in fact.

→MNL model is not appropriate for bicycle behavior & this data?

② RL model

Firstly we think people consider future utility:
GRL model(Generalized Recursive Logit model)

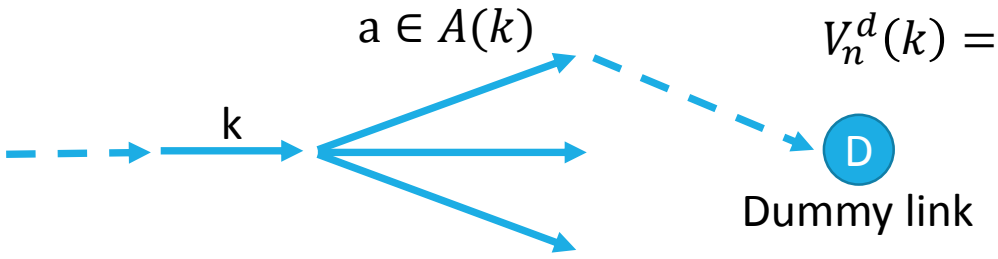
t-value of the time discount rate = ∞

∴model **does not rely on time discount rate**

→ employ **RL model**

$$u_n(a|k) = v_n(a|k) + \mu\varepsilon_n(a) + V_n^d(a)$$

$$V_n^d(k) = E[\max_{a \in A(k)} \left(v_n(a|k) + \mu\varepsilon_n(a) + V_n^d(a)\right)]$$



explanatory variable: distance, right turn, …

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Consideration on data size

1.The whole data inside Matsuyama route line PP Bicycle trip data

The data is too big to estimate

```
Error: cannot allocate vector of size 81.8 Mb

Hide Traceback
Rerun with Debug

4. array(rep(z), dim = c(L, L))
3. fn(par, ...)
2. (function (par)
   fn(par, ...))(c(-0.433055004593762, 1.46685813068546, 1.19202723185824,
   0.0169633906925379, -0.149746420246263))
1. optim(b0, fr, method = "BFGS", hessian = TRUE, control = list(fnscale = -1))
```

2.Data Divided into 4 area

The data is too biased and the the number of link alternatives is too small to estimate

①in some of the divided areas, all of the people go to the same D; cannot be estimated

②in some of the divided areas, dL (the difference of calculated likelihood on each stage) does not converge

Simulation: Parameter Estimation of RL model

Calculation condition ： How we simulated trip data?

1)We **reduced the number of links** by narrowing the object area
2)We set 1 **OD pair** inside the area;
D is Matsuyama-shi Station, O is Matsuyama-Higashi Highschool in the central area
3)Taking a questionnaire from a citizen of Matsuyama
4)He specified some paths which he usually uses
5)He declared **possibility of each route choice**
6)We simulated trip data based on that questionnaire
7)We prepared a sparse **network based on real network**

Result of Parameter Estimation

```
> ##########  estimation result ###########
> print(res) #最尤法結果
$par
[1] -0.1037526  0.2262198

$value
[1] -270.2278

$counts
function gradient
      25       NA

$convergence
[1] 0

$message
NULL

$hessian
           [,1]       [,2]
[1,] -191.39733  20.75748
[2,]   20.75748 -29.01753

> print(Lc)  #
[1] -713.0909
> print(LL)
[1] -270.2278
> print((Lc-LL)/Lc) #尤度比
[1] 0.6210472
> print((Lc-(LL-length(b)))/Lc)
[1] 0.6182425
> print(b) #パラメータ値
[1] -0.1037526  0.2262198
> #theta <- exp(b[3])/(1+exp(b[3]))
> #print(theta) #時間割引率
> print(tval) #t値
[1] -1.378578  1.170375
>
> ########## calculation time #############
> message("ALL COMPLETED!¥n")
ALL COMPLETED!

> print(proc.time()-t)
   ユーザ    システム       経過
    119.78       0.14     120.76
```

explanatory variable:
distance, the number of turning right

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To estimate in RL model

When the data is big (about over 4GB; R memory limitation),

we should reduce network data into small area

×not reduce trip data … network data will become small, but the number of trip data is also small to estimate

When hhh is dead,

explanatory variables are not working

Appendix: PP Data characteristics

In some situation Matsuyama PP is too small.

(the effect of the cases that the same person behaves in the exactly same situation is big)