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Mobility Analysis in Downtown of Yokohama City

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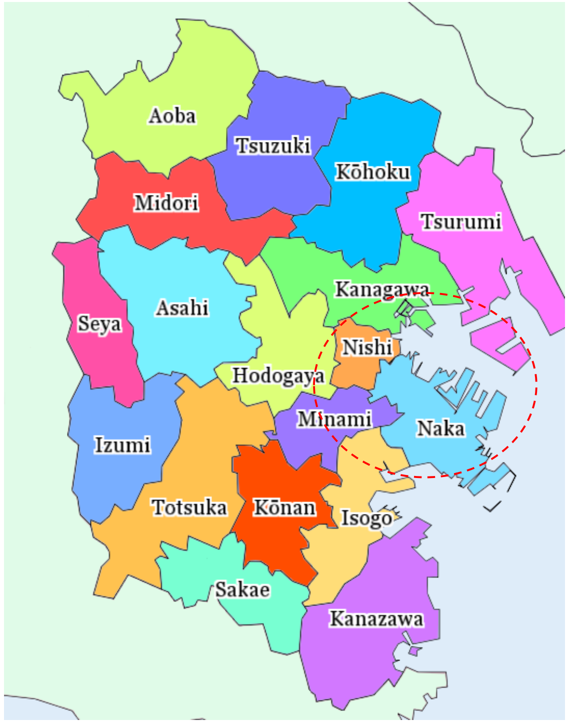
A brief OD analysis

Origin	Destination	Trips	Origin	Origin	Destination	Destination
104	104	266	Naka-ku	中区	Naka-ku	中区
103	103	98	Nishi-ku	西区	Nishi-ku	西区
104	103	42	Naka-ku	中区	Nishi-ku	西区
212	212	41	Atsugi	厚木市	Atsugi	厚木市
110	110	40	Totsuka	戸塚区	Totsuka	戸塚区
102	102	37	Kanagawa-ku,	神奈川区	Kanagawa-ku,	神奈川区
103	212	32	Nishi-ku	西区	Atsugi	厚木市
(blank)	104	26	Unknown	Unknown	Naka-ku	中区
112	112	25	Asahi-ku,	旭区	Asahi-ku,	旭区
104	(blank)	25	Naka-ku	中区	Unknown	Unknown
103	104	24	Nishi-ku	西区	Naka-ku	中区
110	104	22	Totsuka	戸塚区	Naka-ku	中区
115	104	22	Sakae-ku,	栄区	Naka-ku	中区

...

Naka Ward is a regional commercial center and the old main business district of Yokohama, while Nishi Ward is a regional commercial center and the main business district of modern Yokohama.



Motivation - Downtown Yokohama

From 1,522 registered trips, 430 (28.3%) are within the downtown area (Naka-ku + Nishi-ku). In addition, 682 trips (44.8%) have downtown as origin and 688 trips have downtown as final destination (45.2%).

The mobility issues within downtown area are then quite relevant.

Car is the most preferred mode (after cycling and walking) o

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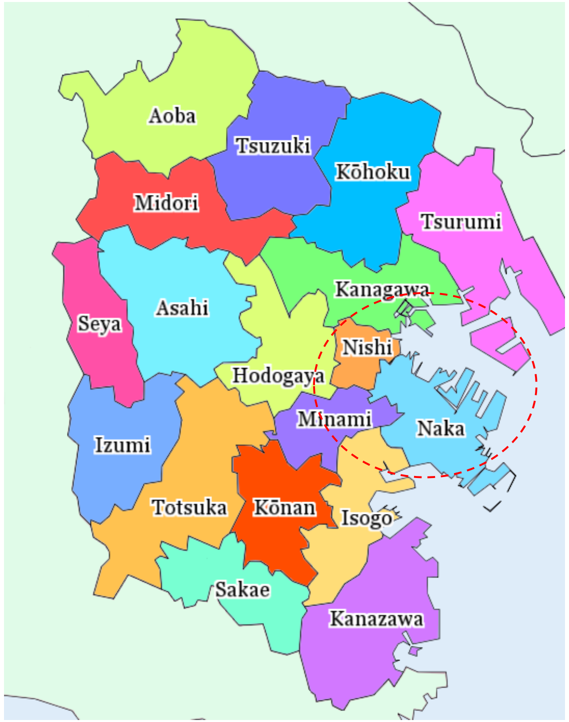
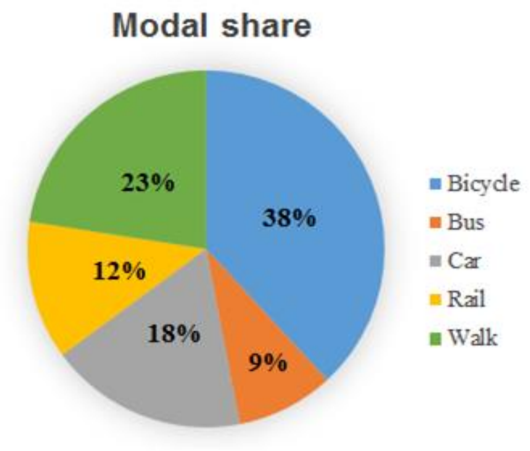
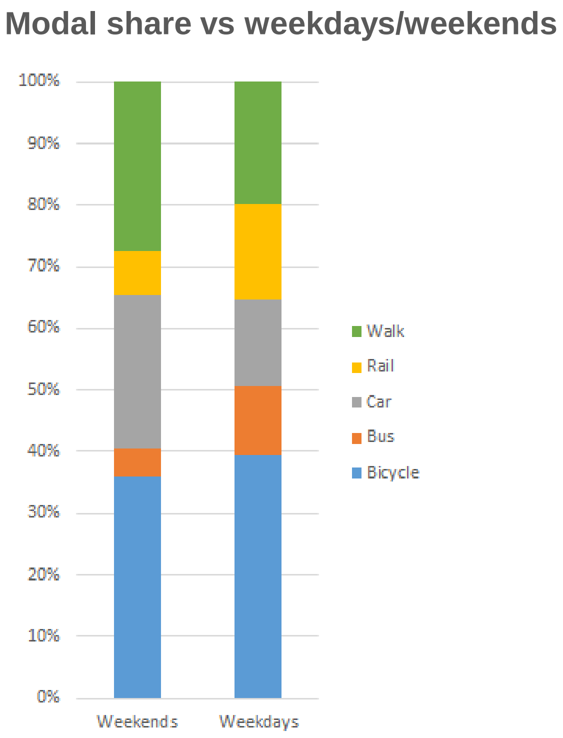
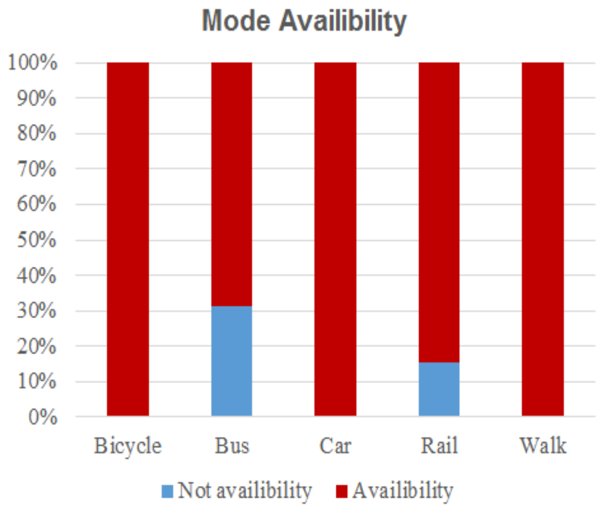


Data Descriptive

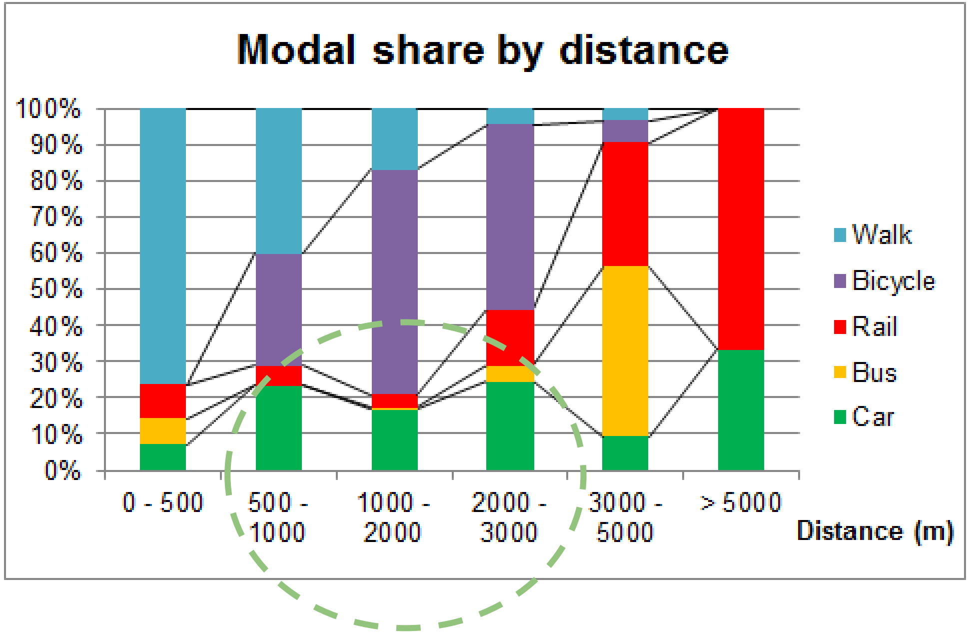






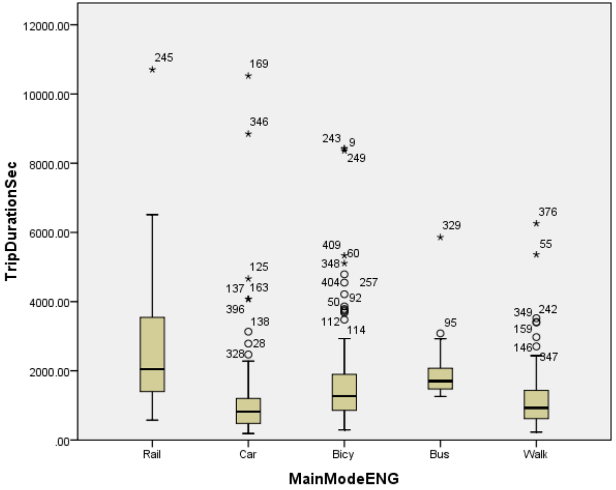
Xx % of the trips are work-related

Data Descriptive (cont’d)



In addition:

- Bus is mainly used for trips between 3 and 5 km.
- Bicycle is preferred for trips between 500 and 3,000 m.
- Car trips for distances 500 - 3000 m could eventually be reduced in favor of bicycles or bus (or shared mobility modes).



Research question and objectives

Why the car is preferred over train and bus for the internal downtown trips?

Objectives

- To find which factors contribute to car preference
- To compare the outcomes of different modeling approaches
- To discuss policy implications related to the reduction of car use in favor of shared mobility, non-motorized and public transport modes.

Utility Equation

$$U_{train} = C_{train} + \alpha.TC_{train} + \beta.TT_{train} + \lambda_{train}.WP + \mu_{train}.WD + \varepsilon_1$$

$$U_{bus} = C_{bus} + \alpha.TC_{bus} + \beta.TT_{bus} + \lambda_{bus}.WP + \mu_{bus}.WD + \varepsilon_2$$

$$U_{car} = C_{car} + \alpha.TC_{car} + \beta.TT_{car} + \lambda_{car}.WP + \mu_{car}.WD + \varepsilon_3$$

$$U_{bike} = C_{bike} + \alpha.TC_{bike} + \beta.TT_{bike} + \lambda_{bike}.WP + \mu_{bike}.WD + \varepsilon_4$$

$$U_{walk} = 0 + \alpha.TC_{walk} + \beta.TT_{walk} + \lambda_{walk}.WP + \mu_{walk}.WD + \varepsilon_5$$

Where

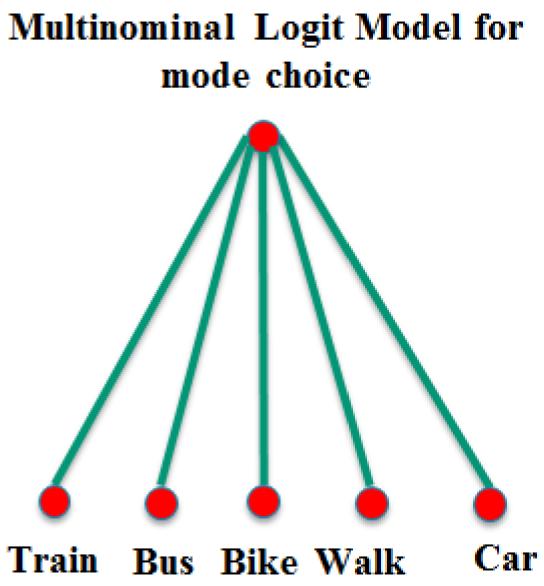
- TC: Travel Cost
- TT: Travel Time
- WP: Working activities
- WD: Weekday

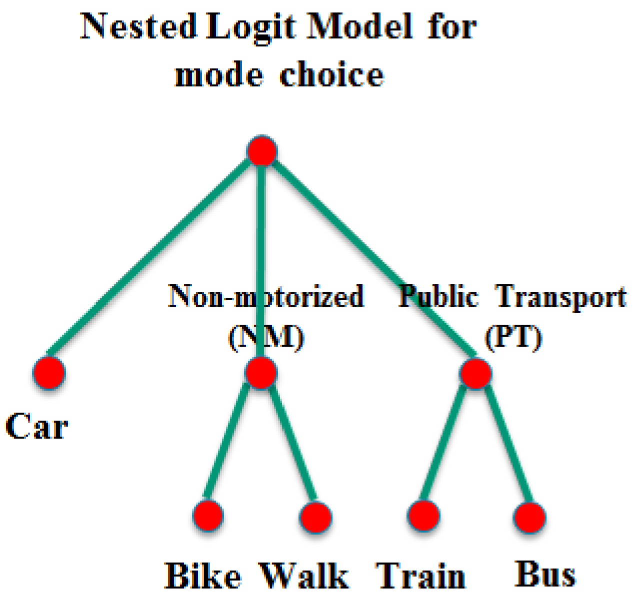
$C_{car} = f$ (parking cost*, distance*)

$C_{train,bus}$ => $Fare_{train,bus}$

First, let’s compare 2 basic model approaches

For making a trip within downtown area





Probability

$$Pr(Bus) = Pr(Bus|PT) \times Pr(PT)$$

$$Pr(Train) = Pr(Train|PT) \times Pr(PT)$$

$$Pr(Walk) = Pr(Walk|NM) \times Pr(NM)$$

$$Pr(Bike) = Pr(Bike|NM \times Pr(NM)$$

$$Pr(Car) = \frac{\exp(Car)}{\exp(V_{Car}) + \exp(V_{PT} + \theta PT \times \Delta PT) + \exp(V_{NM} + \theta NM \times \Delta NM)}$$

Estimation Results

Coefficients	MNL				NL			
	Estimate	Std. Error	Pr(z)		Estimate	Std. Error	Pr(z)	
C_{train}	-0.008	0.000	< 2.2E-16	***	3.540	0.403	< 2.2E-16	***
C_{bus}	-0.008	0.000	< 2.2E-16	***	3.304	0.363	< 2.2E-16	***
C_{car}	-0.006	0.000	< 2.2E-16	***	25.283	0.048	< 2.2E-16	***
C_{bike}	-2.911	0.463	3.2E-10	***	0.454	0.198	2.21E-02	*
Travel time	-31.744	4.179	3.0E-14	***	-6.475	0.196	< 2.2E-16	***
Travel Cost	-18.479	0.000	< 2.2E-16	***	-0.013	0.000	< 2.2E-16	***
Weekday (train)	-0.002	0.000	< 2.2E-16	***	4.313	0.304	< 2.2E-16	***
Weekday (bus)	-0.003	0.000	< 2.2E-16	***	2.932	0.324	< 2.2E-16	***
Weekday (car)	-0.007	0.000	< 2.2E-16	***	-2.178	0.216	< 2.2E-16	***
Weekday (bike)	0.507	0.178	4.4E-03	**	1.769	0.275	1.3E-10	***
Weekday (walk)	-0.494	0.178	5.6E-03	**	3.374	0.219	< 2.2E-16	***
Work Purpose (train)	-0.003	0.000	< 2.2E-16	***	-0.326	0.376	3.9E-01	
Work Purpose (bus)	0.001	0.000	< 2.2E-16	***	1.128	0.331	6.5E-04	***
Work Purpose (car)	-0.005	0.000	< 2.2E-16	***	-1.144	0.414	5.8E-03	**
Work Purpose (bike)	0.086	0.204	6.7E-01		2.282	0.220	< 2.2E-16	***
Work Purpose (walk)	-0.079	0.204	7.0E-01		-3.104	0.179	< 2.2E-16	***
θ_{PT}	-	-	-		1.224	0.205	2.253E-09	***
θ_{NM}	-	-	-		3.826	0.264	< 2.2E-16	***
Sample size		430				430		
Initial Loglikelihood		-472.40				-472.40		
Converged Loglikelihood		-123.65				-778.82		
Rho		0.74				0.64		
Adjusted Rho		0.70				0.68		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Remarks

The observed utility of car trips changes drastically when using a NL model!

Much reduced influence of time and cost of travel in overall utility.

Weekday: The observed influence of weekday in modal choice changes when using a nested structure (**Public transportation and walking** are prefered over car during weekdays). → **Car use is much higher on weekends!**

Work activities: Influence on upper lower nest is similar than the observed with MNL. More notorious difference in utilities for car and walking (-), **bike and bus (+)**.

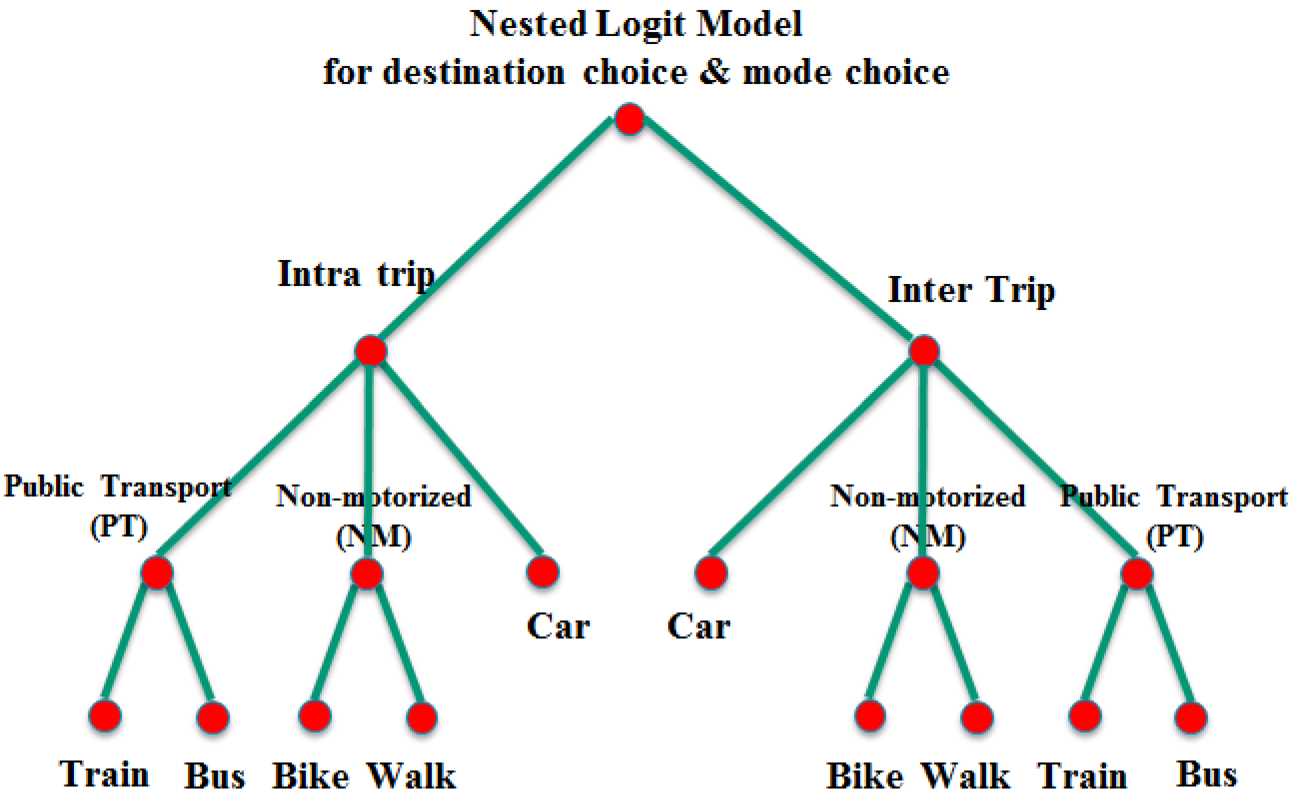
Policy implications:

Provision of PT services **during the weekends** → **Bus** related to non-working activities (leisure purposes!).

Capturing the influence of destination

Now, how does the (destination choice) influence the modal choice?

- Internal trips
- Interzonal trips



Nested Logit Model
for destination choice & mode choice
Intra trip
Inter Trip
Public Transport
(PT)
Non-motorized
(NM)
Car
Car
Non-motorized
(NM)
Public Transport
(PT)
Train
Bus
Bike
Walk
Bike
Walk
Train
Bus

Final remarks

The type of modeling structure does matter, under the use of NL model the relevance of specific modal choices is more notorious in significance and magnitude of the utility of the trips. (Better answers for the matter of reducing car use in downtown Yokohama, with less influence of cost and enhanced influence of purpose and day of the week).

Given our considered variables for the utility functions, we can increase the cost of using car to discourage its use (parking fee or limiting parking spaces on weekends?)

THANK YOU

Appendix

Estimation of parameters:

- Average cost of parking in downtown (yen / day): 1400, 1700 (Naka-ku / weekdays, weekends); 1350, 1850 (Nishi-ku / weekdays, weekends)
- Fuel price (as of 2009) ~ 120 yen / L
- Fuel consumption of passenger cars (urban area): 15.1 km/L

Sources:

https://www.dieselnet.com/standards/jp/fe.php#ld

http://e.pacifico.co.jp/facility/parking.html

http://www.listsothebysrealty.co.jp.e.nm.hp.transer.com/yswalker/%E6%A8%AA%E6%B5%9C%E4%B8%AD%E8%8F%AF%E8%A1%97%E3%81%AB%E8%BF%91%E3%81%84%E9%A7%90%E8%BB%8A%E5%A0%B4/

$$\Pr(Bus|PT) = \frac{\exp\left(\frac{V_{Bus}}{\theta PT}\right)}{\exp\left(\frac{V_{Bus}}{\theta PT}\right) + \exp\left(\frac{V_{Train}}{\theta PT}\right)}$$

$$\Pr(Train|PT) = \frac{\exp\left(\frac{V_{Train}}{\theta PT}\right)}{\exp\left(\frac{V_{Bus}}{\theta PT}\right) + \exp\left(\frac{V_{Train}}{\theta PT}\right)}$$

$$\Pr(Walk|NM) = \frac{\exp\left(\frac{V_{Walk}}{\theta NM}\right)}{\exp\left(\frac{V_{Bike}}{\theta NM}\right) + \exp\left(\frac{V_{Walk}}{\theta NM}\right)}$$

$$\Pr(Bike|NM) = \frac{\exp\left(\frac{V_{Bike}}{\theta NM}\right)}{\exp\left(\frac{V_{Bike}}{\theta NM}\right) + \exp\left(\frac{V_{Walk}}{\theta NM}\right)}$$

$$\Pr(PT) = \frac{\exp(V_{PT} + \theta PT \times \Delta PT)}{\exp(V_{Car}) + \exp(V_{PT} + \theta PT \times \Delta PT) + \exp(V_{NM} + \theta NM \times \Delta NM)}$$

$$\Pr(NM) = \frac{\exp(V_{NM} + \theta NM \times \Delta NM)}{\exp(V_{Car}) + \exp(V_{PT} + \theta PT \times \Delta PT) + \exp(V_{NM} + \theta NM \times \Delta NM)}$$

$$\Delta PT = \log\left(\exp\left(\frac{V_{Bus}}{\theta PT}\right) + \exp\left(\frac{V_{Train}}{\theta PT}\right)\right);$$

$$\Delta NM = \log\left(\exp\left(\frac{V_{Walk}}{\theta NM}\right) + \exp\left(\frac{V_{Bike}}{\theta NM}\right)\right)$$