กรมการขนส่งทางราง

PART 1

แบบจำลองการคาดการณ์ผู้โดยสารระบบราง (Rail passenger demand forecasting models) ในประเทศญี่ปุ่น

บรรยายโดย...JICA Expert Team

กิจกรรมถ่ายทอดความรู้ ครั้งที่ 1/2564

โครงการเพื่อพัฒนาแบบจำลองการคาดการณ์ความต้องการเดินทางด้วยระบบรางและการพัฒนาโครงข่ายระบบขนส่งมวลชนทางรางในเขตกรุงเทพและปริมณฑล (พื้นที่ต่อเนื่อง) ระยะที่ 2 (M-MAP 2)

วันพุธที่ 24 พฤศจิกายน 2564

ณ ห้อง Infinity Ballroom 2 ชั้น G Pullman Bangkok King Power

The Project for Enhancing Capacity of Formulation of the Second Mass Rapid Transit Master Plan in Bangkok Metropolitan Region (M-MAP2)

Why the Demand Forecast Model Specialized for Railways is Needed? Examples from Japanese Railway Master Plan

JICA Expert Team

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TMA Railway Demand Forecast Model

- Developed by The Council of Transport Policy for TMA Railway Master Plan

  An independent council under MLIT

  Secretariat: Railway Bureau and Kanto Regional Bureau (MLIT)

- Railway Master Plan Model for Tokyo Metropolitan Area

  Tokyo, Kanagawa, Saitama, Chiba, and a part of Ibaraki Pref.

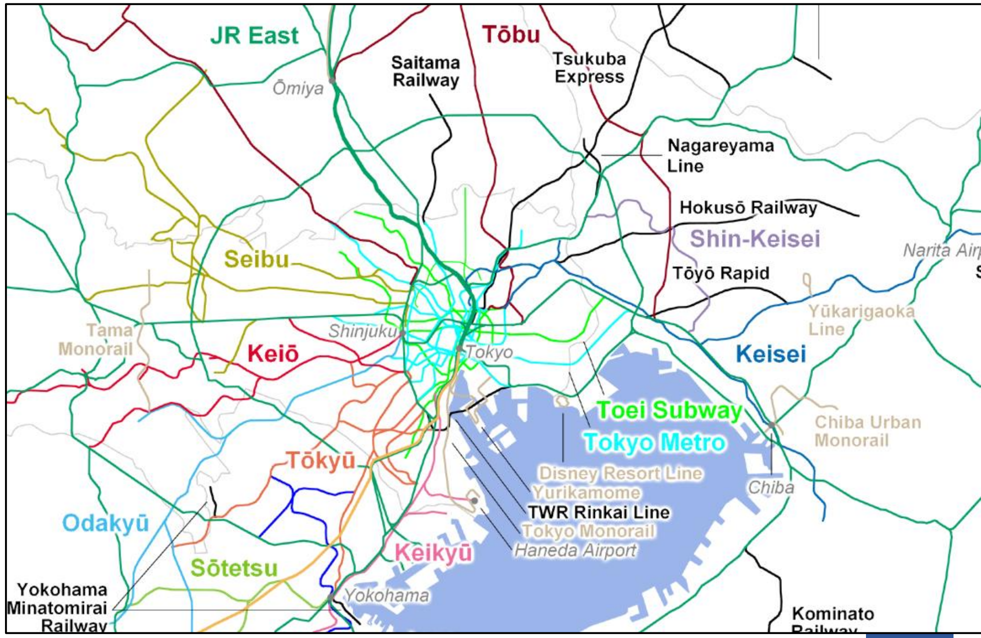
  Study area approx. 50km radius from CBD

  Population of 30 Million

- 4-Step Model

- Latest Model Developed in 2016

  Which we will cover this model today



Roles of Demand Forecast Model

In CTPP No.18 (2000 TMA Railway Master Plan), the demand forecast result was utilized in several aspect, such as

- New line investment priority setting

  Demand forecast result will be one of the criteria in multi-criteria analysis for priority setting

- Public policy responsive analysis

  Five major policies, namely, congestion reduction, travel time saving, reinforcing urban structures, airports & HSR stations access improvement, and universal design & seamless transfer, were analyzed based on the indices obtained from the demand forecast model.

- Subsidy Analysis

  Analysis on who (local govt, central govt, other public organizations, etc.) benefit from the railway service, and how much the benefit it is. This will help to determine which stakeholder should share the investment cost based on their expected benefit from railway service.

Why the Railway Demand Forecast Model is Needed?

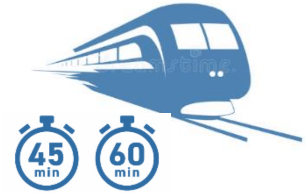
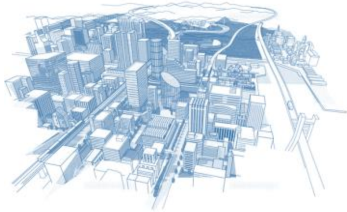
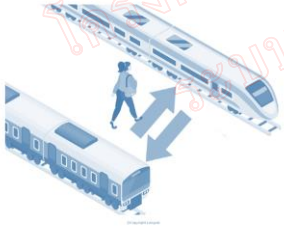
1. To evaluate the railway policies and goals
2. To provide a precise passenger demand forecast, <u>specifically for railway passenger</u>
   - below items are examples of issue taken into considered in Tokyo model
     - Zone with high competition between each railway lines should be divided in more detail, while zone with low railway demand could be aggregated.
     - Railway station access model is introduced
     - Reconstruction with the difference of passenger demand in each railway section between estimated value and the actual data within 10% difference.
3. To provide a state-of-the-art model based on the latest result from academic researches

Development History

	Analysis	Features of Model
CUTP No.15 (1972) Target year 1985	Demand forecasting and other related analyses	▪ First introduction of 4-Step Model ▪ 40 analysis zones
CTPP No.7 (1985) Target year 2000	Evaluation of the congestion rate in the most congested section	▪ Analysis of morning peak-hours by consider only working and schooling commuter ▪ Introduction of Disaggregate Travel Demand Model ▪ 658 analysis zones
CTPP No.18 (2000) Target year 2015	▪ Congestion alleviation, time savings analysis ▪ Evaluation of railway service profitability ▪ Cost-effectiveness analysis (CEA) ▪ Service continuity	▪ Include daytime traffic analysis (not only peak hour) for profitability estimation ▪ Introduction of congestion parameter ▪ Introduction of Probit Model ▪ Introduction of Airport and HSR access model ▪ 1,812 analysis zones
CTPP No.198 (2016) Target year 2030		▪ Increase the group of trip purpose ▪ Analysis by age groups due to the effect of population aging ▪ 2,843 analysis zones

CTPP No.18: Evaluation by Policy

Ranges of KPIs were designed for policy evaluation in Tokyo Railway Master Plan in 2000

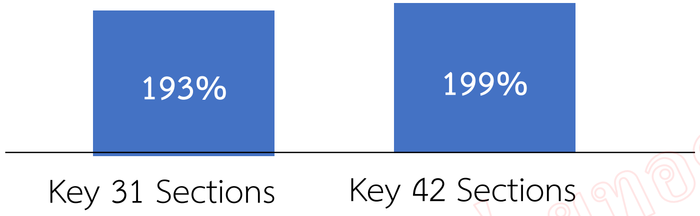
	Goal	KPI	Objects	W/O PRJ		With PRJ
	**Goal 1** Alleviate in-train congestion	Congestion ratio	Most congested section	195%		172%
		Congestion length	Over-congested sections (Low / Med. / High)	L / M / H		L / M / H
	**Goal 2** Shorten travel time	Time saving (total)	Entire network	100%	-5,000H	99.95%
		Time saving (key sections)	Key sections	45 min	-10min	35 min
	**Goal 3** Reinforce urban structures & functions	Total access/egress time	To/from nearest station	100%	-5,000H	99.95%
		Total time /# of transfer	From sub-center to center From regional core to CBD	55 min (3)	-15min	30 min (0)
	**Goal 4** Improve access to airports & High Speed Rail stations	Total time /# of transfer	Whole passengers	100% (100)	-1500H -5000T	88% (85)
		Time /# of transfer	From key locations	65 min (2)	-15min	52 min (1)
	**Goal 5** Promote universal design & seamless service	Total number of transfer	Entire network	100%	-45,000T	99.7%
		Time /# of transfer	Key sections	38 min (1)	-3min	35 min (0)

Goal 1. Alleviate in-train congestion

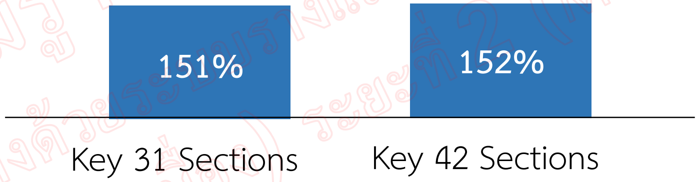
In-train congestion can be evaluated with average congestion ratio & length of over-congested sections.

Congestion Ratio

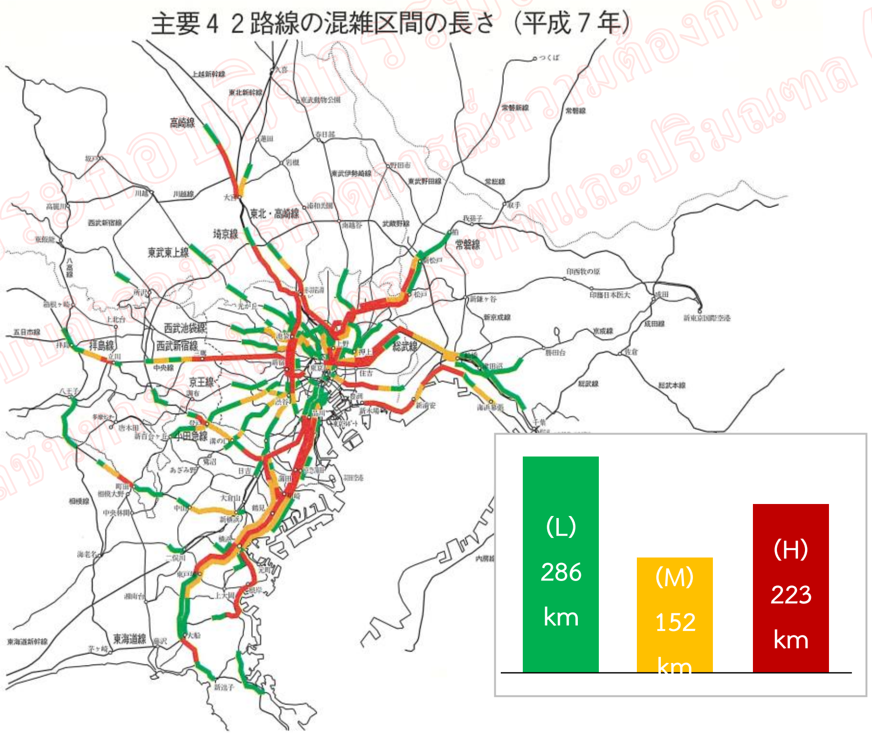
Year 1996
(actual situation before the master plan)

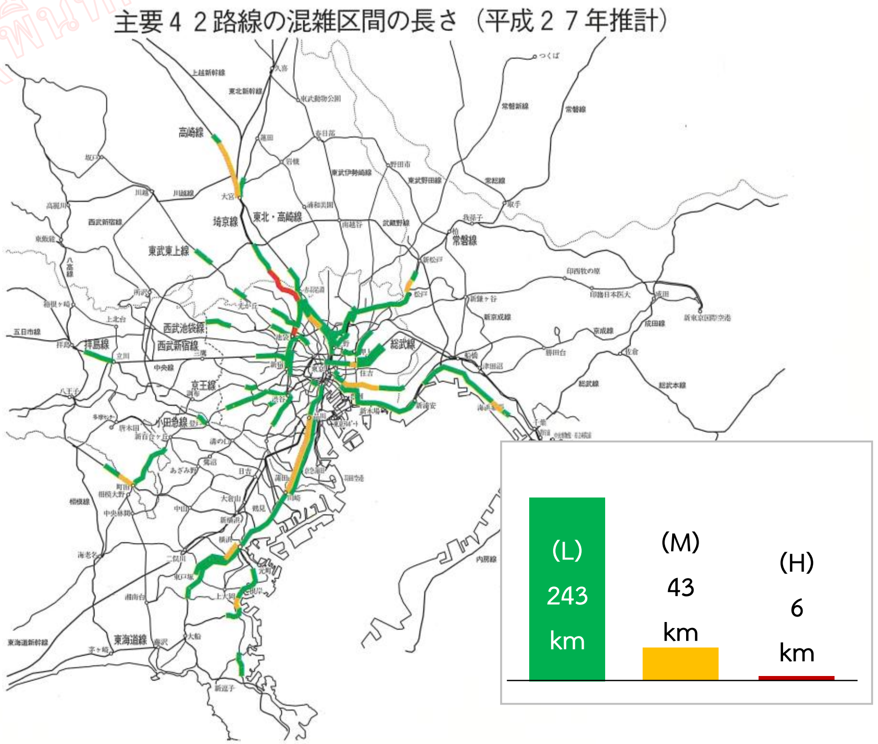


Year 2016
(estimation after the implementation)



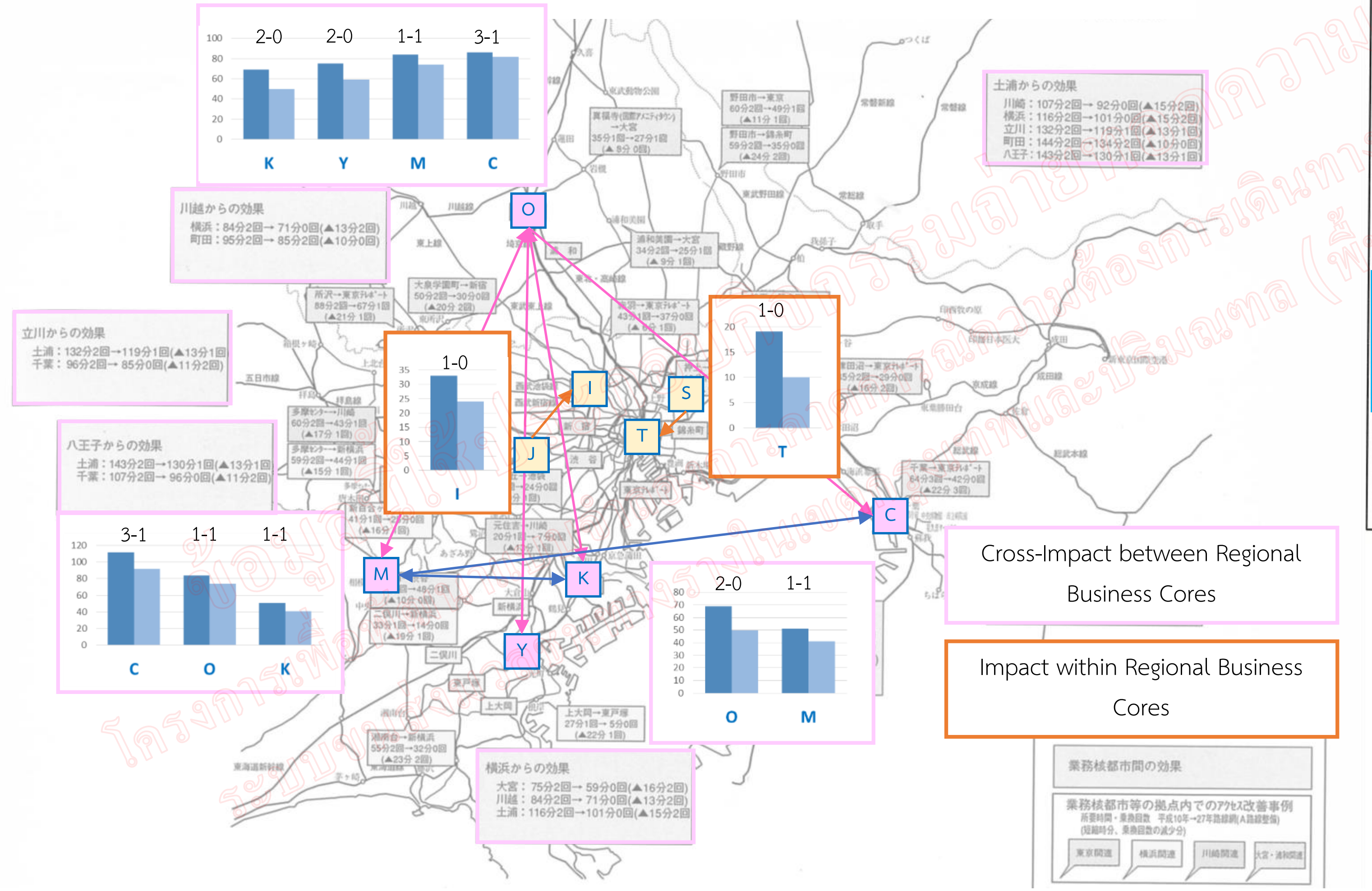
Length of over-congested sections

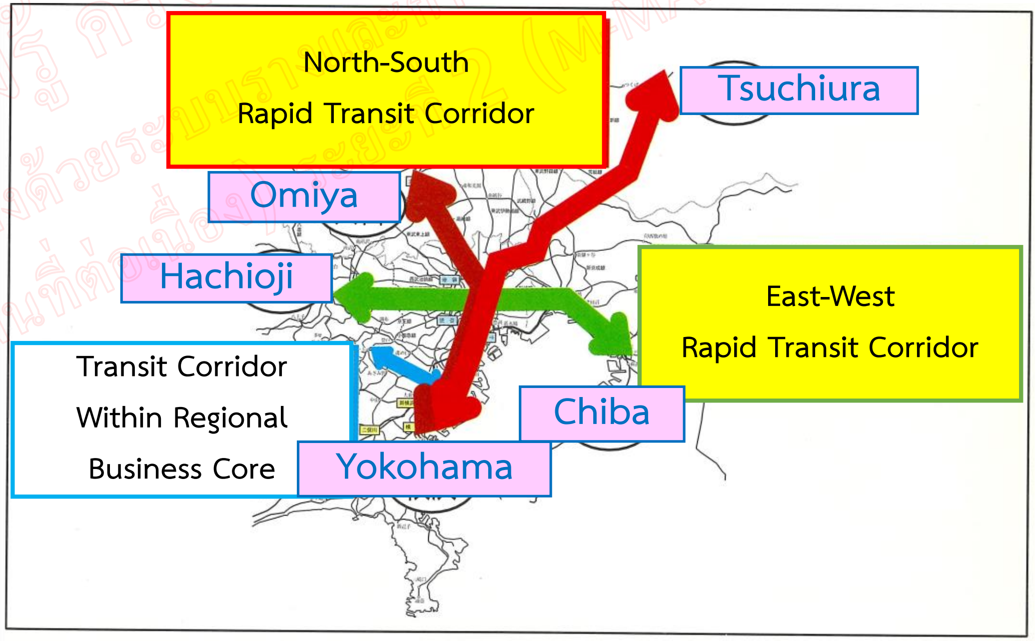




Travel time & no. of transfer among CBDs and periphery's cores can describe strength of urban structures & functions. (In case of BMA: Bangkok CBD – Bang Khae – Min Buri – Nonthaburi – Rangsit – Samut Prakan)

Impact on Urban Structure (TO-BE)





Goal 5

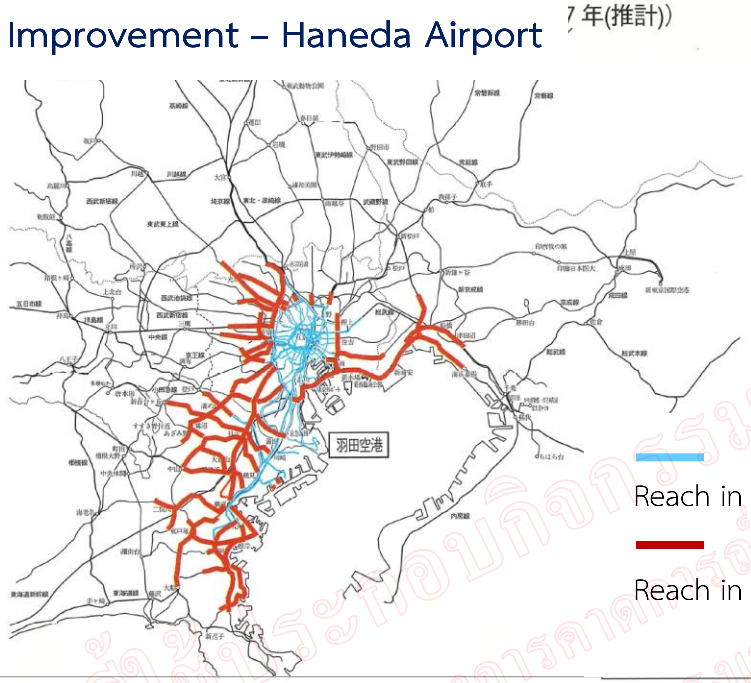
Promote universal design & seamless service

Change in number of transfers

Goal 4. Improve access to airports & High Speed Rail stations

Access time and no. of transfers to Suvarnabhumi, Don Mueang and Bang Sue from key locations.

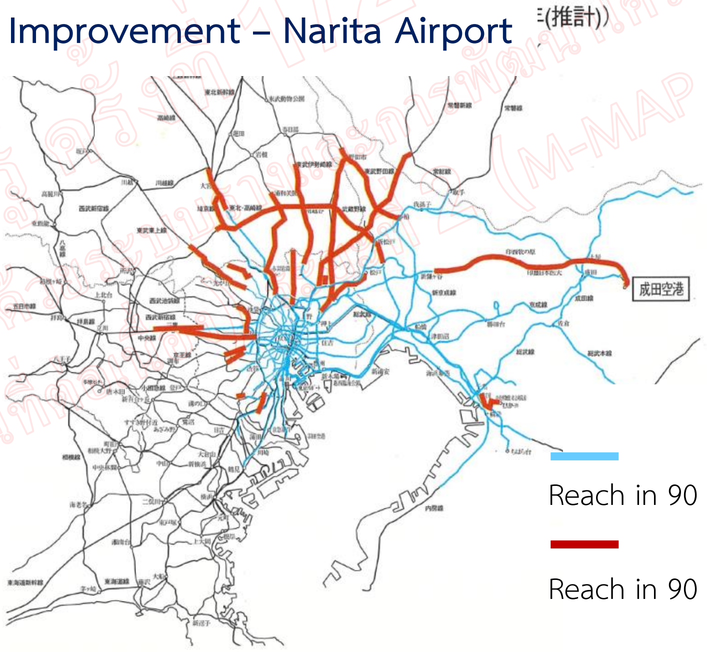
Access Improvement – Haneda Airport



Reach in 60 min (1996)

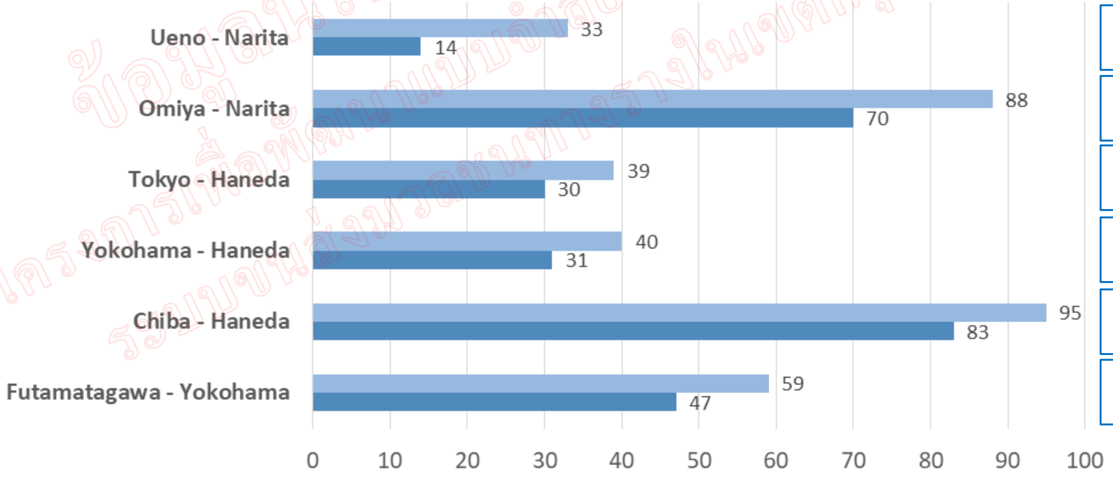
Reach in 60 min (2016 est.)

Access Improvement – Narita Airport



Reach in 90 min (1996)

Reach in 90 min (2016 est.)



-19 min	0	0	Transfer
-18 min	1	1	Transfer
-09 min	1	0	Transfer
-09 min	1	0	Transfer
-12 min	1	1	Transfer
-12 min	1	0	Transfer

Goal 5

Promote universal design & seamless service

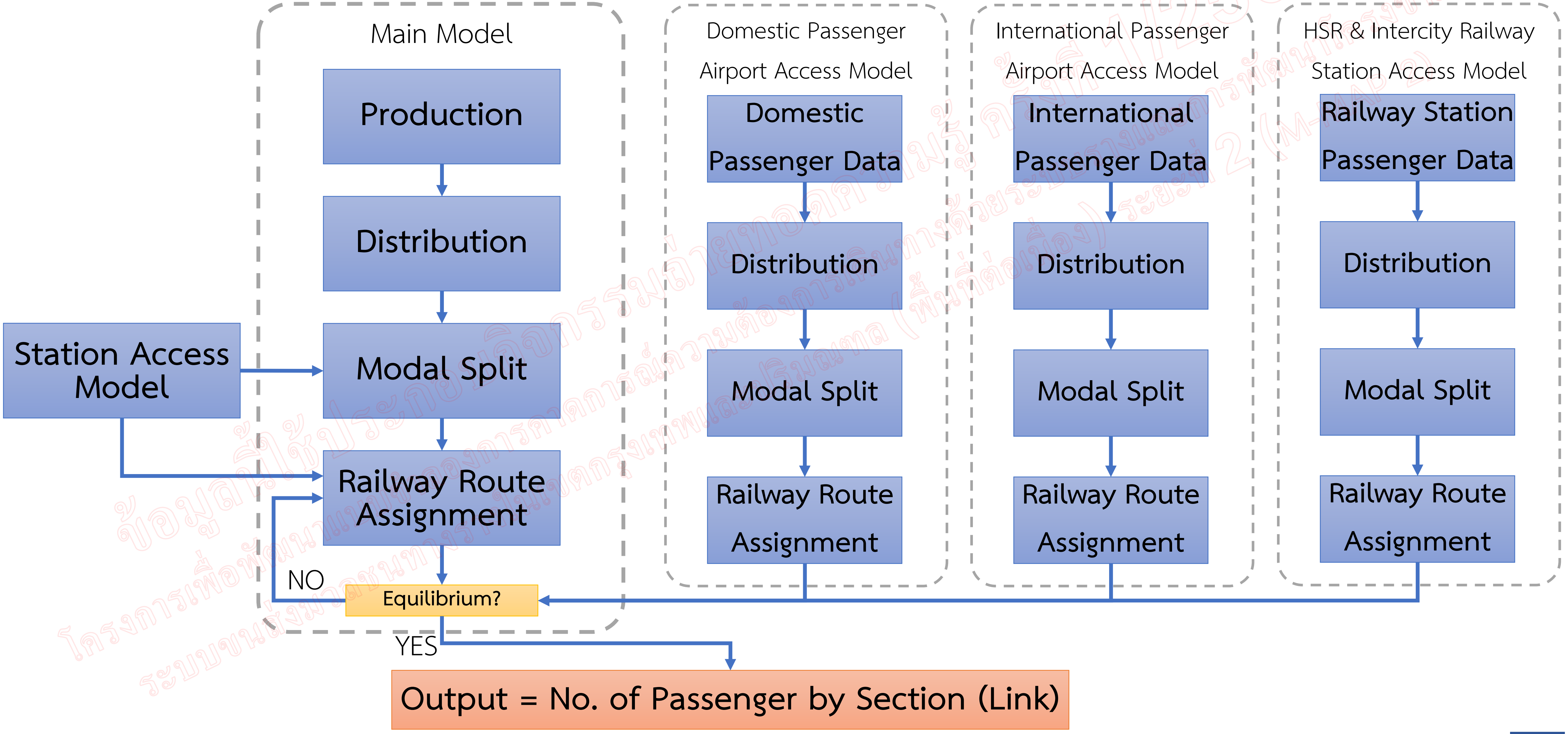
Change in number of transfers

CTPP No.18: Investment Priority Evaluation

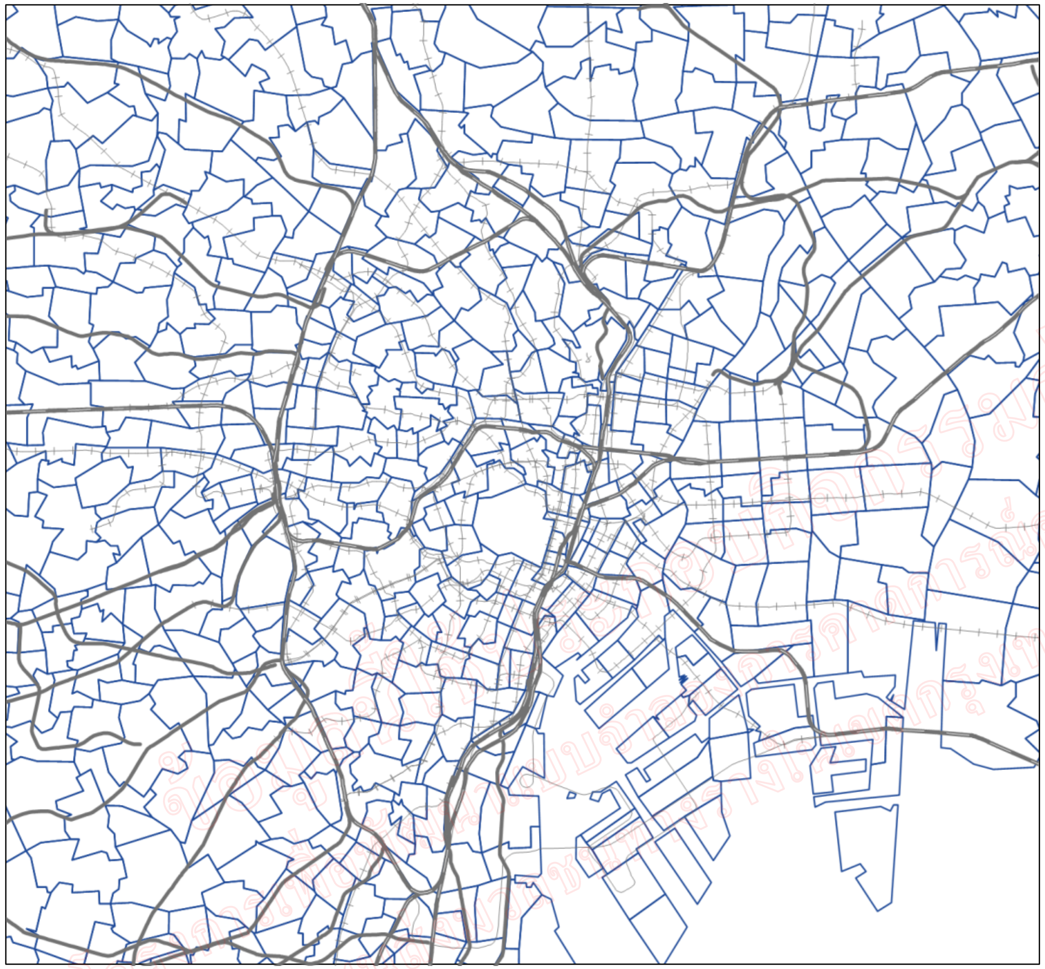
Proposals were evaluated consistently with the evaluation criteria, thus providing accountability & objectivity.

Study Route	Route / Section	Length	Demand (Traffic Density)	Accomplishment of Policy Goals / Socio-Economic Impact							Financial Viability			Maturity of Project Formulation
				Decongestion	Seamless Transfer	Travel Time	Urban Structure	Access to HSR/Airport	Relevance/ Impact to Other Lines	Benefit / Cost	Net Cashflow	Rate of Subsidy	Investment Cost	
1	A	3.6	319	Good	Avg.	Good	Good	Avg.	xx	6.7	5.4	0%	628	Operating body
2	B	8.5	95	Poor	Poor	Poor	Poor	Poor	xx	1.0	2.4	80%	3,236	Willingness of LGU
3	C	11.4	91	Avg.	Poor	Good	Poor	Poor	xx	2.3	2.7	50%	2,282	Financing capacity
4	D	6.6	75	Avg.	Poor	Good	Avg.	Poor	xx	3.0	1.7	80%	1,351	Etc.
5	E	12.3	111	Good	Good	Avg.	Avg.	Avg.	xx	2.8	2.6	60%	8,363	
...96														

Demand Forecast Model in CTPP No.198: Overall Flow



Main Model: Structure



2,843 analysis zones + 64 external zones = 2,907 zones

Trip Purpose	
1) Home to Work	6) Work - Business
2) Home to School	7) Work to Home
3) Home to Private	8) School to Home
4) Non Home-Based Private	9) Private to Home
5) Home to Business	10) Business to Home

Time Period		
AM Peak (purpose 1-2)	Off Peak (purpose 3-6)	PM Peak (purpose 7-10)

Age Group (for Home to Work*)	
Production Model	Every 5 years, until 85+
Distribution Model	Female: 15-34, 35-64, 65-74, 75+ Male: -64, 65-74, 75+
Modal Split Model	-64, 65+
Route Assignment Model	

*For other trip purposes, see slide 6

Major Data Input

- 2010 National Census (for Production)
- 2008 Person-Trip Survey (for Distribution and Modal Split)
- 2010 Metropolitan Transport Census (for Route Assignment)
- Other railway passenger statistics for reconstruction and calibration

Main Model: Structure

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Main Model: Production

Trip Rate Method

$$G_{ipa} = \alpha_{ipa} \cdot X_{ipa}$$

$$\alpha_{ipa} = \frac{g_{ipa}}{x_{ipa}}$$

Where

G_{ip}: **Future** trip generated from zone i for trip purpose p, age group a

X_{ip}: **Future** population index from zone i for trip purpose p, age group a

α_{ip}: Trip generation rate from zone i for trip purpose p, age group a

g_{ip}: **Current** trip generated from zone i for trip purpose p, age group a

x_{ip}: **Current** population index from zone i for trip purpose p, age group a

Same applies with attraction, but with different population index

Main Model: Production

Population Index and Trip Rate by Trip Purpose

Trip Purpose	Generation		Attraction	
	Population Index	Trip Rate	Population Index	Trip Rate
1) Home to Work	Number of workers	1.000	Number of employment	1.000
2) Home to School	Number of students	1.000	Number of school seats	1.000
3) Home to Private	Number of people who stay at home during the daytime*	0.716	Daytime population	0.265
4) Non Home-Based Private	Daytime population	0.237	Daytime population	0.237
5) Home to Business	Number of workers	0.075	Number of employment	0.075
6) Work - Business	Number of employment	0.194	Number of employment	0.194
7) Work to Home	Number of employment	0.465	Number of workers	0.466
8) School to Home	Number of school seats	0.713	Number of students	0.715
9) Private to Home	Daytime population	0.312	Nighttime population	0.312
10) Business to Home	Number of employment	0.076	Number of workers	0.076

*equals to = Nighttime pop. – No. of workers – No. of employment + No. of people WFH

Main Model: Distribution

Two steps in Distribution Model

1. Gravity Model

- Used as initial OD trip only on a specific on area, trip purpose, origin, or destination with expected land development

2. Growth Rate Model

- After distribute by Gravity Model on the specific ODs, apply growth rate for the rest based on future population data
- Most of the urban areas are already developed in TMA, so assume no large scale development between OD
- Finally, balance with Fratar Method until total generation = total attraction

Main Model: Distribution

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Fine tune for policy evaluation related to land development

Main Model: Distribution

Gravity Model

$$T_{ijpa} = (\kappa + \delta_0 \cdot d_0) \cdot G_{ipa}^{\alpha} \cdot A_{jpa}^{\beta} \cdot c_{ij}^{(\gamma+\delta_0 \cdot d_0+\sum_k \delta_k \cdot d_k)}$$

Where

T_{ij}: **Future** no. of trip from zone i travel to zone j

A_j: **Future** Trip attracted to zone j

c_{ij}: Generalized cost of trip from zone i to j

δ_0, d_0: CBD, sub-CBD parameter and dummy

δ_k, d_k: k^{th} distance parameter and dummy

$\alpha, \beta, \gamma, \kappa$: other gravity model parameters

Note: CBD, sub-CBD and distance dummy may be excluded from some trip purpose and age group models

Model Variables

Variables	Detail
Generation	Trip generated, calculated from Generation Model (10,000 person)
Attraction	Trip attracted, calculated from Attraction Model (10,000 person)
Generalized Cost	OD generalized cost calculated from Modal Split Model
<10 km Dummy	1 if road distance between OD is in dummy range, 0 otherwise
10-20 km Dummy	
20-30 km Dummy	
30-40 km Dummy	
40-50 km Dummy	
50-60 km Dummy	
CBD, sub-CBD Dummy	1 if O or D zones (or both) are defined as CBD or sub-CBD, 0 otherwise

Main Model: Distribution

Growth Rate Model

$$T_{ij} = t_{ij} \cdot \frac{G_i}{g_i} \cdot \frac{A_i}{a_i} \cdot \frac{1}{2}\left(\frac{g_i}{\sum_j t_{ij} \cdot \frac{A_j}{a_j}} + \frac{a_j}{\sum_i t_{ij} \cdot \frac{G_i}{g_i}}\right)$$

Where

t_{ij}: **Current** no. of trip from zone i travel to zone j

g_i: **Current** Trip generated from zone i

a_j: **Current** Trip attracted to zone j

	1	…	j	…	J	
1	T_{11}	…	…	…	T_{1J}	G_1
⋮	⋮	⋱			⋮	⋮
i	⋮		T_{ij}		⋮	⋮
⋮	⋮			⋱	⋮	⋮
J	T_{J1}	…	…	…	T_{JJ}	G_J
	A_1	…	…	…	A_J	$\sum_{i=1}^{J} G_i = \sum_{j=1}^{J} A_j$

Note: use T_{ij} from Gravity Model if already specified by Gravity Model

Main Model: Modal Split

Two steps in Modal Split Model

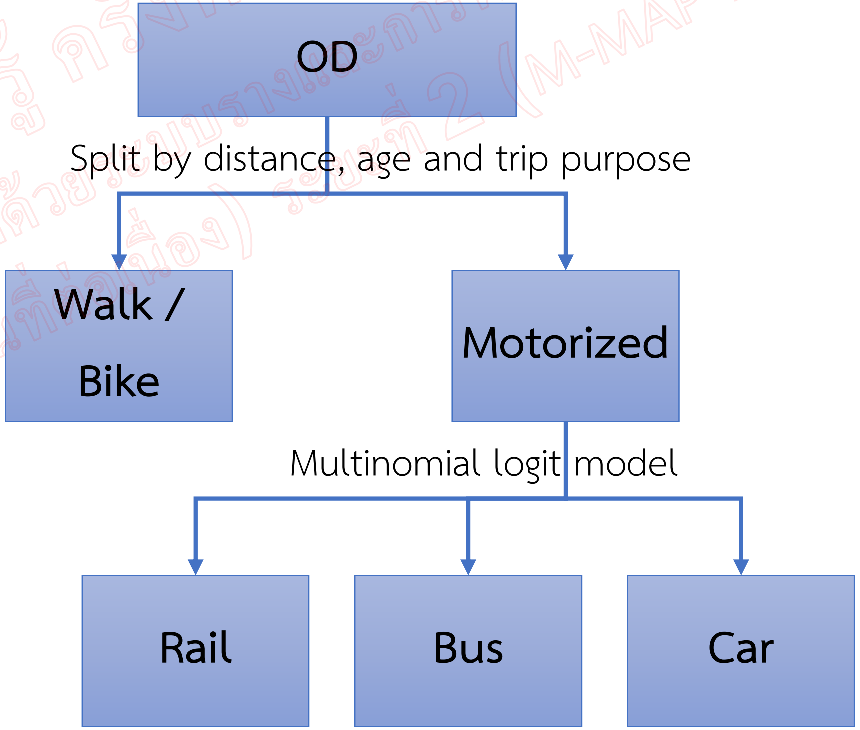
(Nest structure, but not Nested Logit Model)

1. Motorized – Non-Motorized Split

- Fixed the non-motorized share (walk and bicycle) based on the distance, age and trip purpose

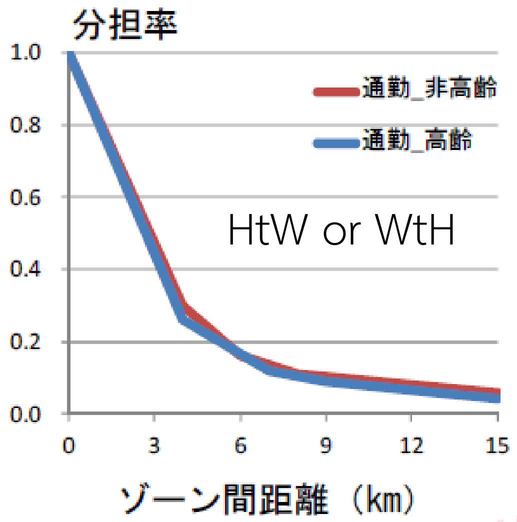
2. Motorized Modal Split

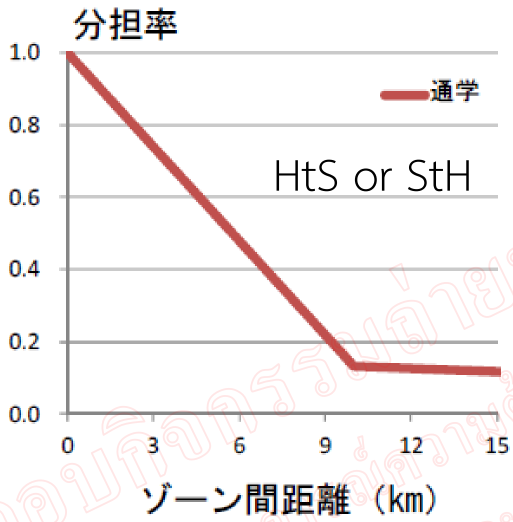
- Split motorized mode by rail, bus and car
- Multinomial Logit Model
- For rail choice, consider log sum of station access model as one of the variables

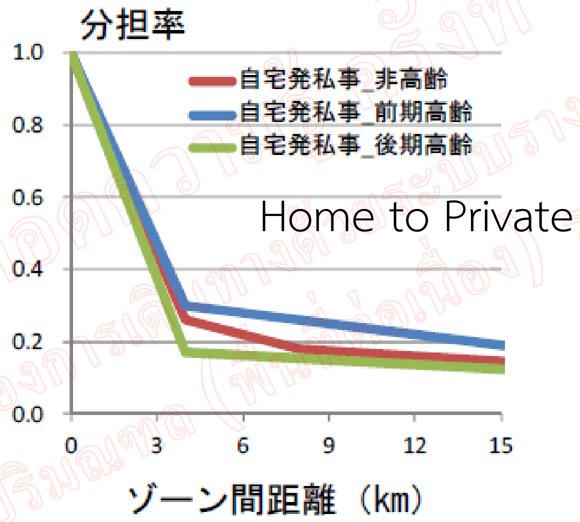


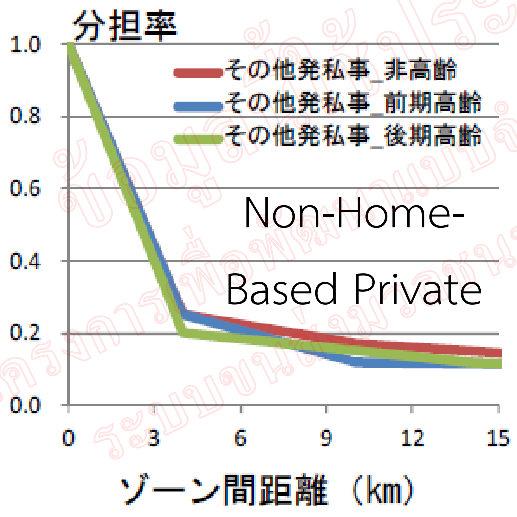
Main Model: Modal Split

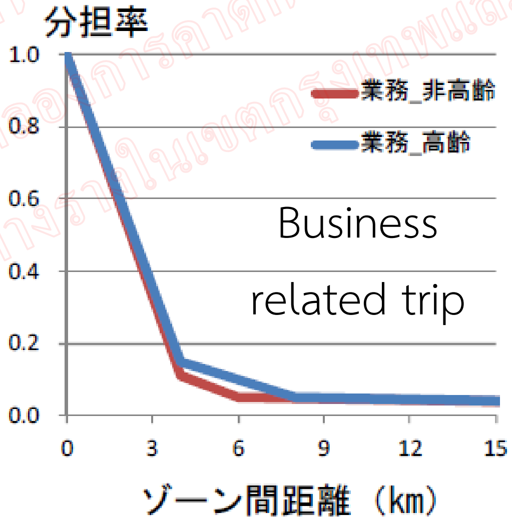
Motorized – Non-Motorized Split











Red: 64 y.o. or less

Blue: 65-74 y.o. (or 65+ if there is no green line)

Green: 75 y.o. or more

Y axis: share of non-motorized mode

X axis: distance (km)

Composed based on the result of 2008 Person-Trip Survey

Main Model: Modal Split

Motorized Modal Split

$$P_i = \frac{exp(V_i)}{\sum_{i=1}^{n} exp(V_i)}$$

$$V_i = \sum_k (\theta_k \cdot X_{ik})$$

Where

P_i = Probability of selecting mode i

V_i = Utility of selecting mode i

n = Number of transport mode, here = 3 (rail, bus, car)

θ_k = k^{th} utility parameter

X_{ik} = k^{th} utility variable of mode i

Model Variables

Variables	Detail
Travel Cost (Yen)	RAIL: rail fare BUS: bus fare CAR: VOC (fuel, maintenance) + toll fee
Travel Time (Minute)	RAIL: boarding + transfer + waiting time BUS: boarding + waiting + access/egress to bus stop time CAR: driving + parking (both O&D) time
Vehicle Ownership (Veh/Person)	(CAR ONLY) Vehicle Ownership per capita (20-84 y.o.)
CBD Dummy	(CAR ONLY) 1 for destination zone in the municipality with car share less than 20%, 0 otherwise
Station Access	(RAIL ONLY) Log-sum of the utility of every mode calculated railway station access model, calculated as sum of log-sum of access and egress
Short Trip Dummy	(CAR ONLY) 1 for OD with distance less than 5km, 0 otherwise
ASC	Alternative specific constant for each mode. Bus as a reference.

For railway fare policy evaluation

Motorized Modal Split

$$P_i = \frac{exp(V_i)}{\sum_{i=1}^{n} exp(V_i)}$$

$$V_i = \sum_k (\theta_k \cdot X_{ik})$$

Where

P_i = Probability of selecting mode i

V_i = Utility of selecting mode i

n = Number of transport mode, here = 3 (rail, bus, car)

θ_k = k[th] utility parameter

X_{ik} = k[th] utility variable of mode i

For station access/feeder mode policy evaluation

Model Variables

Variables	Detail
Travel Cost (Yen)	RAIL: rail fare BUS: bus fare CAR: VOC (fuel, maintenance) + toll fee
Travel Time (Minute)	RAIL: boarding + transfer + waiting time BUS: boarding + waiting + access/egress to bus stop time CAR: driving + parking (both O&D) time
Vehicle Ownership (Veh/Person)	(CAR ONLY) Vehicle Ownership per capita (20-84 y.o.)
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Main Model: Modal Split

Estimates		Home to Work, Work to Home				HtS, StH	
		-64		65+		All age	
		parameter	t-value	parameter	t-value	parameter	t-value
Travel Cost (yen)	All	−0.00123	−10.4	−0.000940	−7.34	−0.00561	−13.1
Travel Time (min)	All	−0.0482	−18.2	−0.0389	−13.8	−0.0102	−2.13
Vehicle Ownership	CAR	1.13	7.23	2.45	12.9	0.972	3.35
CBD Dummy	CAR	−1.72	−21.3	−0.847	−8.57	−0.571	−2.05
Station Access	RAIL	0.446	33.6	0.504	24.0	0.148	4.93
Short Trip Dummy	CAR	0.665	6.13	0.530	4.33	2.18	6.87
ASC	BUS	−0.773	−7.65	0.248	1.98	4.28	14.0
	RAIL	2.82	21.8	2.73	17.0	4.80	14.8
Adjusted R^2		0.740		0.545		0.975	
Hit Ratio		90.3		79.9		93.8	
Travel Time VOT (yen/min)		39.3		41.3		1.81	
N		9,763		3,689		2,786	

Main Model: Railway Route Assignment

Multinomial Probit Model

$$P_m^{c-r} = \int_{\varepsilon_1=-\infty}^{\varepsilon_m+V_m^{c-r}-V_1^{c-r}} \cdots \int_{\varepsilon_m=-\infty}^{+\infty} \cdots \int_{\varepsilon_M=-\infty}^{\varepsilon_m+V_m^{c-r}-V_M^{c-r}} \phi(\varepsilon)\, d\varepsilon_M \cdots d\varepsilon_1$$

$$\phi(\varepsilon) = (2\pi)^{-\frac{M}{2}} |\Sigma|^{-\frac{1}{2}} \exp\left(-\frac{1}{2}\varepsilon\Sigma^{-1}\varepsilon^T\right)$$

$$\Sigma = \sigma^2 \underbrace{\begin{pmatrix} L_1 & L_{12} & \cdots & L_{1M} \\ L_{12} & L_2 & \cdots & L_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ L_{1M} & L_{2M} & \cdots & L_M \end{pmatrix}}_{\text{Covariance Matrix for distance}} + \underbrace{\sigma_0^2 I}_{\text{Covariance Matrix for other route characteristics}}$$

Covariance Matrix for distance   Covariance Matrix for other route characteristics

$$\eta = \frac{\sigma^2}{\sigma_0^2}$$

$$\Sigma = \sigma_0^2 \begin{pmatrix} \eta L_1 + 1 & \eta L_{12} & \cdots & \eta L_{1M} \\ \eta L_{12} & \eta L_2 + 1 & \cdots & \eta L_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ \eta L_{1M} & \eta L_{2M} & \cdots & \eta L_M + 1 \end{pmatrix}$$

$$V_m = \sum_k (\theta_k \cdot X_{mk})$$

Model Variables

Variables	Detail
Fare (Yen)	Total route fare from origin station to destination station
Boarding Time (Min)	Total boarding time from origin station to destination station
Transfer Time, Horizontally (Min)	Time spent on walking horizontally while transferring the train
Transfer Time, Vertically (Min)	Time spent on moving vertically (elevator, escalator, etc.) while transferring the train
Waiting Time (Min)	Total time waiting for train boarding, including the first ride. Assume as a half of headway.
Congestion Index	Calculated from travel time and congestion rate, see below
Station Access	Log-sum of the utility of every mode calculated railway station access model
Variance Ratio	Similarity of a certain route to other routes

Congestion Index

$$CI_m = \sum_j \left(B_{mj} \cdot \left(\frac{CR_{mj}}{100}\right)^2\right)$$

Where

CI_m = Congestion index of route m

B_{mj} = Boarding Time of link j, route m

CR_{mj} = Congestion rate of link j, route m

Multinomial Probit Model

For railway transfer policy evaluation

P_m^c – … $\int_{\varepsilon_1=-\infty}$ … $\int_{\varepsilon_m=-\infty}$ … $\int_{\varepsilon_M=-\infty}$

$$\phi(\varepsilon)=(2\pi)^{-\frac{M}{2}}|\Sigma|^{-\frac{1}{2}}\exp\left(-\frac{1}{2}\varepsilon\Sigma^{-1}\varepsilon^{T}\right)$$

$$\Sigma=\sigma^2\begin{pmatrix} L_1 & L_{12} & \cdots & L_{1M} \\ L_{12} & L_2 & \cdots & L_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ L_{1M} & L_{2M} & \cdots & L_M \end{pmatrix}+\sigma_0^2 I$$

Covariance Matrix for distance — Covariance Matrix for other route characteristics

$$\eta=\frac{\sigma^2}{\sigma_0^2}$$

For policy evaluation related to in-train congestion alleviation

$$\Sigma=\sigma_0^2\begin{pmatrix} \eta L_1+1 & \cdots \\ \eta L_{12} & \cdots \\ \vdots & \vdots & \ddots & \vdots \\ \eta L_{1M} & \eta L_{2M} & \cdots & \eta L_M+1 \end{pmatrix}$$

$$V_m=\sum_k(\theta_k\cdot X_{mk})$$

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Main Model: Railway Route Assignment

	Work				School		Private				Business	
	-64		65+		All Age		-64		65+		All Age	
	parameter	t-value	parameter	t-value	parameter	t-value	parameter	t-value	parameter	t-value	parameter	t-value
Fare	−0.00355	−3.89	−0.00325	−3.09	−0.00415	−3.94	−0.00365	−3.56	−0.00447	−2.84	−0.00314	−2.74
Boarding Time	−0.151	−7.35	−0.0974	−5.62	−0.0800	−5.40	−0.0912	−5.22	−0.102	−3.13	−0.136	−7.35
Horizontal Transfer	−0.242	−6.54	−0.139	−4.22	−0.133	−3.51	−0.205	−3.94	−0.183	−2.60	−0.140	−2.79
Vertical Transfer	−0.313	−4.77	−0.329	−4.91	−0.137	−2.02	−0.221	−2.87	−0.261	−2.10	−0.376	−4.25
Waiting Time	−0.145	−4.24	−0.112	−3.63	−0.0784	−3.37	−0.105	−3.67	−0.120	−2.52	−0.132	−4.07
Congestion Index	−0.0122	−2.50	−0.0335	−5.42	−0.0101	−1.88						
Station Access	0.883	12.7	0.991	10.6	0.908	12.6	0.752	11.4	0.975	4.98	0.888	12.2
Variance Ratio	0.128	2.88	0.022	1.16	0.019	1.08	0.033	1.15	0.253	1.36	0.035	1.32
Adjusted R^2	0.440		0.389		0.433		0.353		0.331		0.490	
Boarding VOT	42.6		30.0		19.3		25.0		22.7		43.2	
Horizon Transfer VOT	68.3		42.7		32.0		56.2		40.9		44.5	
Vertical Transfer VOT	88.1		101		33.1		60.5		58.4		120	
Waiting VOT	40.7		34.3		18.9		28.8		26.9		41.9	
N	1,000		500		500		500		500		500	

Station Access Model

Calculate the share of mode used for railway station access, from walk, bicycle, car, bus

$$P_i = \frac{exp(V_i)}{\sum_{i=1}^{n} exp(V_i)}$$

$$V_i = \sum_k (\theta_k \cdot X_{ik})$$

Where

P_i = Probability of selecting mode i

V_i = Utility of selecting mode i

n = Number of transport mode, here = 4 (walk, bicycle, car, bus)

θ_k = k^{th} utility parameter

X_{ik} = k^{th} utility variable of mode i

Model Variables

Variables	Detail
Non-Motorized Travel Time (Minute)	(WALK, BICYCLE ONLY) WALK: walking time between origin or destination to station BICYCLE: cycling time between origin or destination to station, parking time included
Motorized Travel Time (Minute)	(CAR, BUS ONLY) CAR: travel time between origin or destination to station, parking time included BUS: travel time between origin or destination to station, access/egress time to bus stop included
Travel Cost (Yen)	Total cost spent between origin or destination to station
Elevation Difference	(WALK, BICYCLE ONLY) Elevation difference between origin or destination to station. Reference from 50m mesh elevation data
LN(Frequency)	(BUS ONLY) Business, Private: Ln of frequency per day Work, School: Ln of peak hour frequency, calculated from frequency per day x 0.16
ASC	Alternative specific constant for each mode. CAR as a reference.

Station Access Model

For station access/feeder mode policy evaluation

Calculate the share of mode used for railway station access, from walk, bicycle, car, bus

$$P_i = \frac{exp(V_i)}{\sum_{i=1}^{n} exp(V_i)}$$

$$V_i = \sum_k (\theta_k \cdot X_{ik})$$

Where

P_i = Probability of selecting mode i

V_i = Utility of selecting mode i

n = Number of transport mode, here = 4 (walk, bicycle, car, bus)

θ_k = k[th] utility parameter

X_{ik} = k[th] utility variable of mode i

Model Variables

Variables	Detail
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Transport Hub (Airport, HSR Station) Access Model

- Domestic Passenger Airport Access Model
- International Passenger Airport Access Model
- HSR & Intercity Railway Station Access Model

1. Production Model

- Technically, no production model. Use the passenger data from airport survey or intercity railway survey for generation and attraction

2. Distribution Model

- Apply only growth rate model for OD distribution

3. Modal Split Model

- Multinomial Logit Model, same as Main Model
- Some new variables, including
  - Reliability index (for airport and road)
  - Airport or station specific dummy

4. Route Assignment Model

- Multinomial Logit Model (not Probit)
- Variables are simplified version of the main model
  - No congestion index, no station access
  - Introduce some line specific dummies

Reliability Index

$$RI_i = \alpha \cdot CI_i + \beta_E D_{Ei} + \beta_F D_{Fi} + \beta_T D_{Ti} + \gamma$$

Where

RI_i = Reliability index of route i

CI_i = Congestion index of route i, defined by average travel time/free flow travel time

E = Expressway

F = Four lanes or more road

T = Two lanes road

D_i = Distance of each types of road in route i

α, β, γ = Estimated parameters

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- Some new variables, including
  - Reliability index (for airport and road)
  - Airport or station specific dummy

Fine tune model for the demand from Airport, HSR station (demand from outer zones and tourist)

ain

- No congestion index, no station access
- Introduce some line specific dummies

Reliability Index

$$RI_i = \alpha \cdot CI_i + \beta_E D_{Ei} + \beta_F D_{Fi} + \beta_T D_{Ti} + \gamma$$

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Why Railway Demand Forecast Model is Needed in BMA?

Some expected policy evaluations in railway planning

(based on the discussion in M-MAP2 Blueprint)

- To alleviate traffic congestion in the center
- To strengthen overall railway network n BMR
- To improve accessibility to stations
- To provide value added mass transit services
- To enhance accessibility to global gateways

↓

These policies cannot be evaluated by the previous e-BUM (in 2019 TDS)

↓

A new Railway Demand Forecast Model is required for railway policy evaluation