



# Low Cost Carriers and Transport Network Efficiency

格安航空（LCC）の  
都市間交通ネットワーク効率への影響に関する研究

2015年11月16日

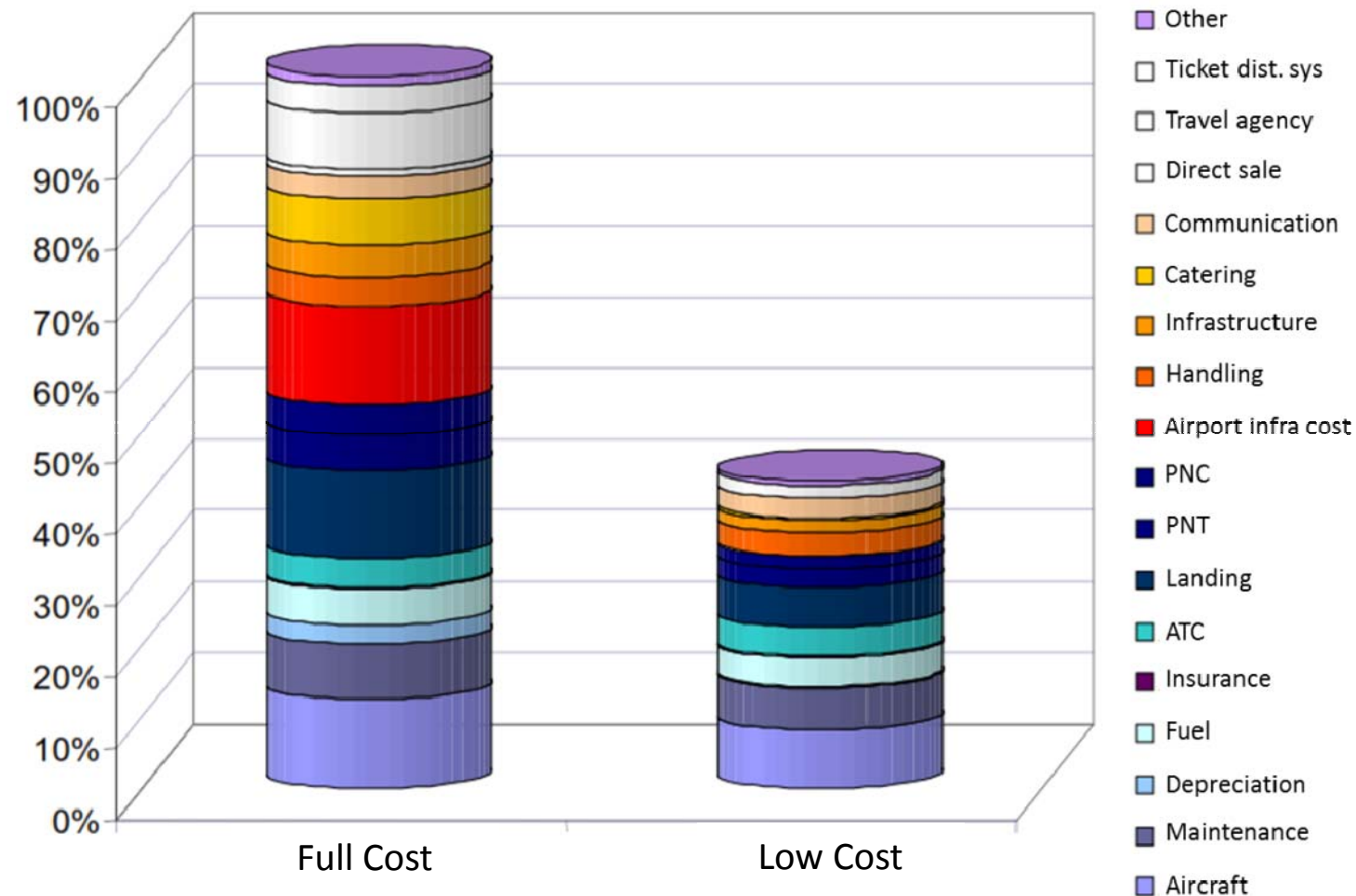
TIRTOM Huseyin

- 1** Introduction はじめに
- 2** Objective 本研究の目的
- 3** Methodology 分析方法
- 4** A Simplified Example 実証分析例
- 5** Conclusion 結論
- 6** Future Works 今後の研究課題

- A Low Cost Carrier is an airline that generally has lower fares with less comforts
- To increase revenue, they may charge for extras (food, baggage etc.)



# Introduction Low Cost vs Full Cost コストの比較 – LCC 対フルコスト



Cost Comparison between BMI (UK) and Easyjet

Source: Flying Off Course: Airline Economics and Marketing (Fourth Edition) - by Rigas Doganis (2010)

# Introduction

## Low Cost vs Full Cost

## コストの比較(英国の場合)

| LCC Characteristics                       | Cost Advantage over FSC (%) |
|---|-----------------------------|
| Higher seating density                    | 16                          |
| Higher aircraft utilization               | 18                          |
| Lower flight and cabin crew cost          | 21                          |
| Cheaper secondary airports                | 25                          |
| Single aircraft / outsourcing maintenance | 27                          |
| Minimal station cost                      | 34                          |
| Fewer passenger services                  | 39                          |
| No agents or GDS                          | 45                          |
| Reduced sales / reservation cost          | 48                          |
| Smaller administration and fewer staff    | 51                          |
| Total                                     | 49 %                        |

### Cost Comparison between BMI (UK) and Easyjet

Source: Flying Off Course: Airline Economics and Marketing (Fourth Edition) - by Rigas Doganis (2010)

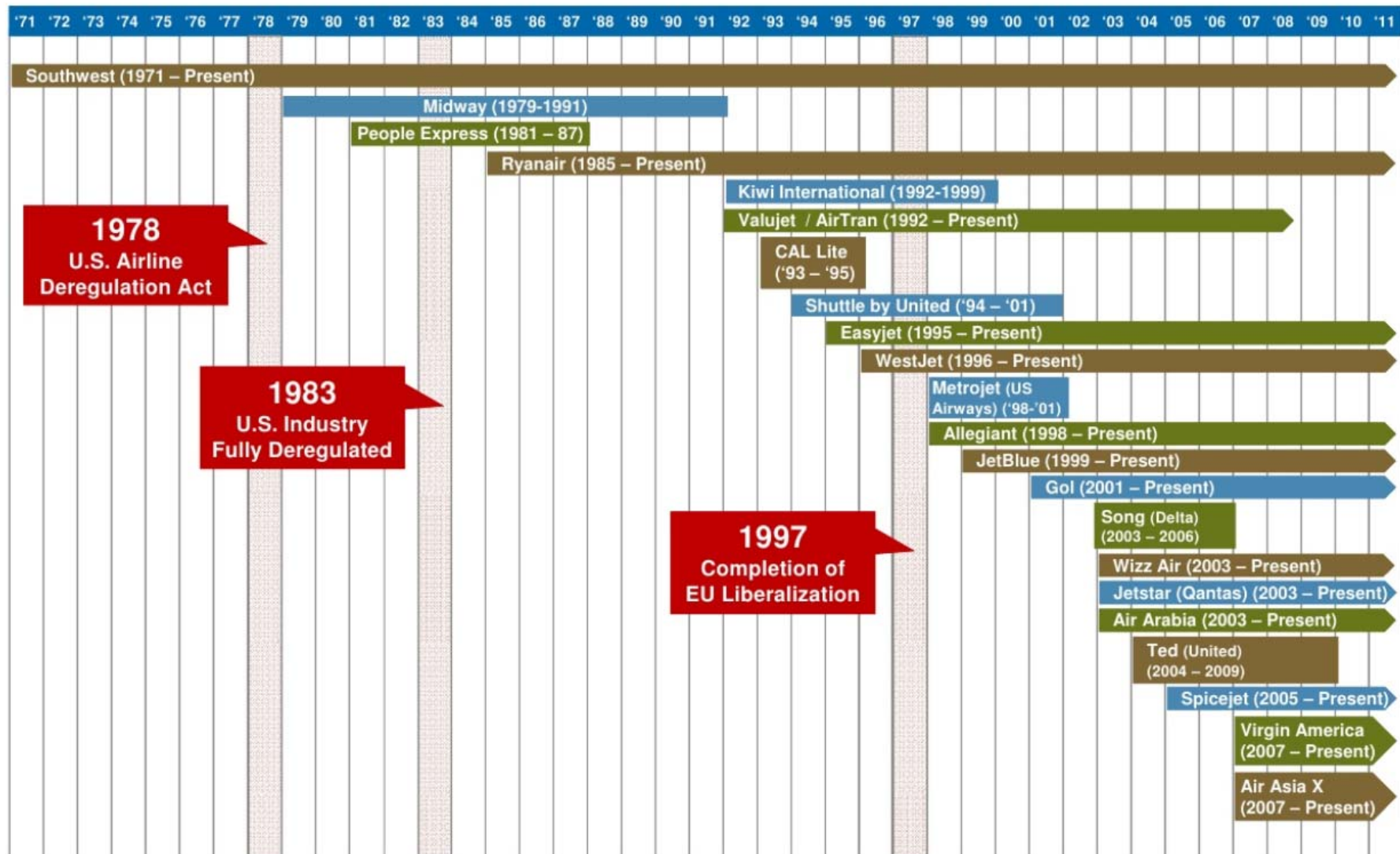
### FSCs（フルサービス航空）

- Have hub-and-spoke networks with larger geographical coverage
- Use major airports, provides frequent and convenient flights
- Provide comfortable flights (business class, larger seats, frills etc. )
- Provide better ground services and customer support
- Extend their destinations with codeshare agreements
- Have loyalty programs and better brand image

# Introduction

## LCC development in the world

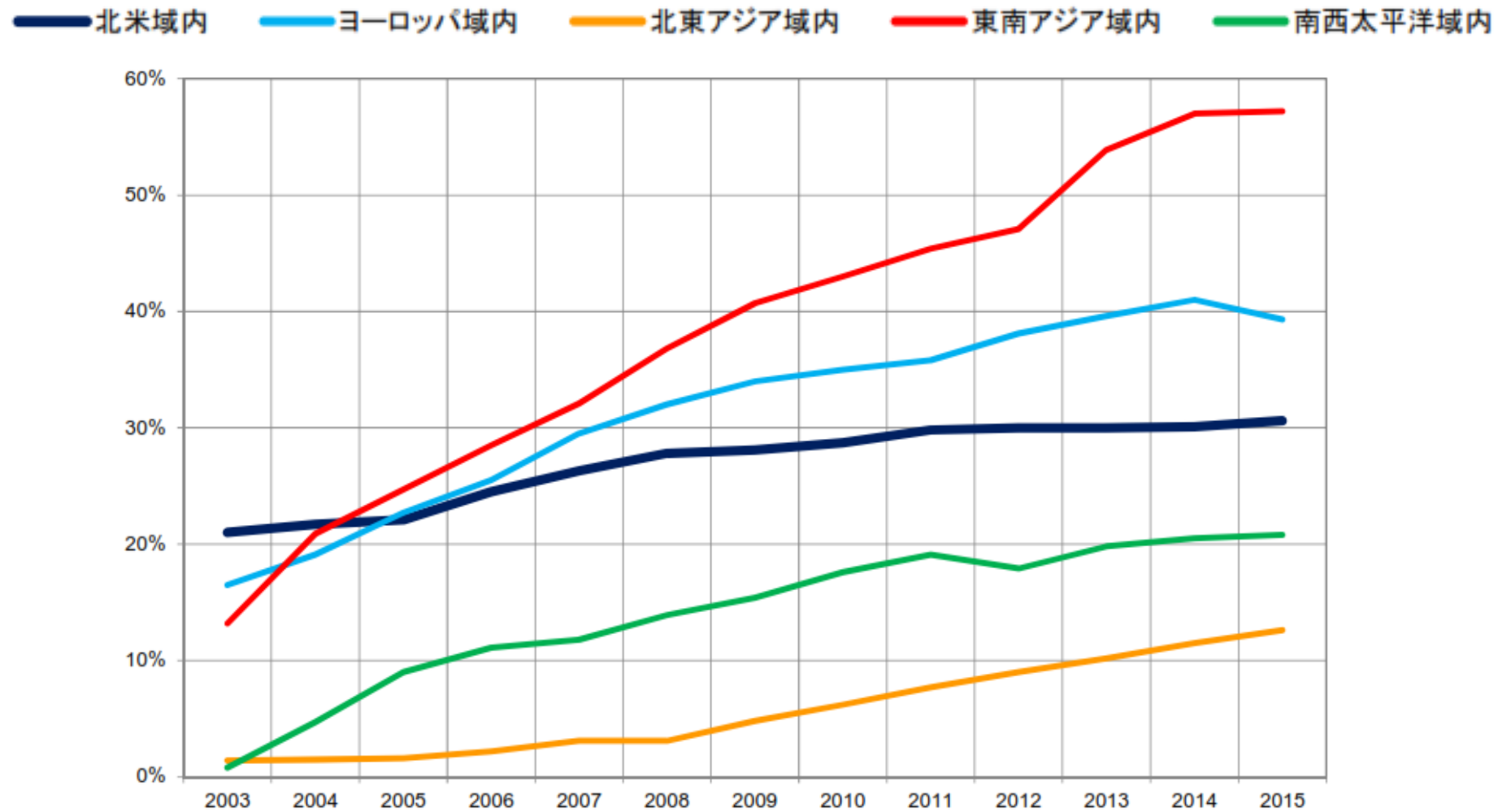
## 世界のLCC発展



Source: Mark Diamond, ICF, SH&E



# Introduction LCC market share in the world 世界のLCC市場シェア



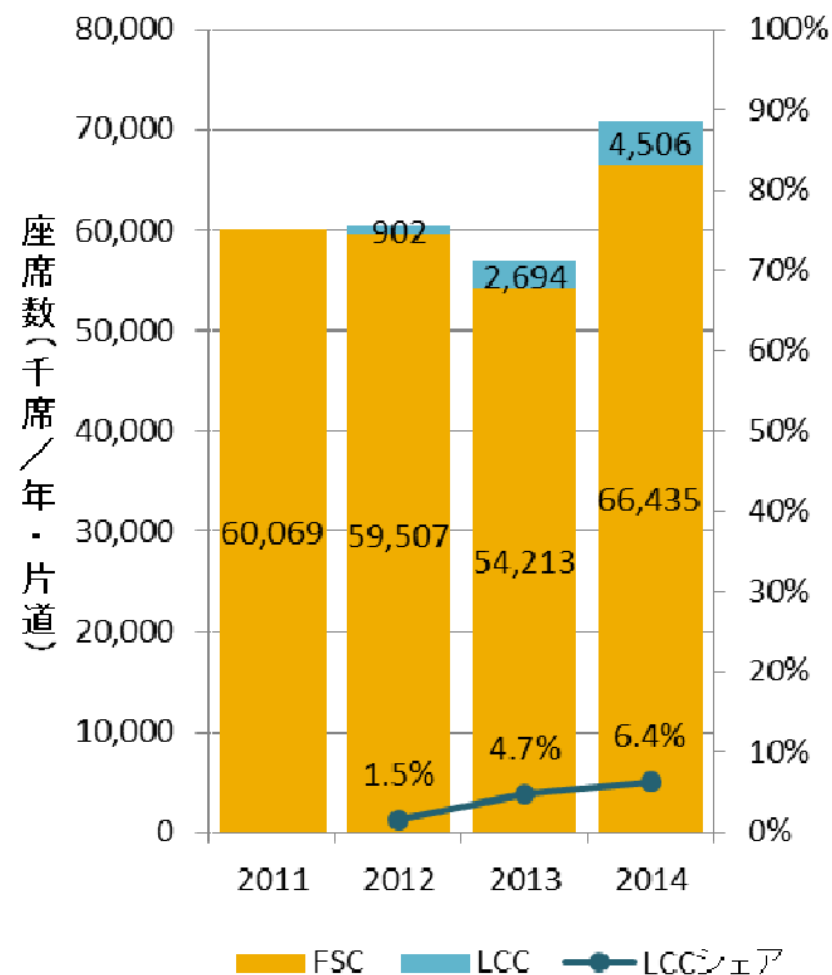
Source: CAPA, Centre for Aviation



LCCs' entry into the Japanese Market



LCCs' market share in the domestic market



Source: Yoichi Hirotsu, Development Bank of Japan

Source: LCC 参入による地域への経済波及効果に関する調査研究, 2015

- LCCs are considered good for tourism and regional economy.
- Airport managers and local governments support LCC airlines
- Japanese Government also welcomes LCC growth.
- Government aims 14% domestic LCC share by 2020.

LCCs are growing fast in a favorable environment. But, how much growth is safe for JAL, ANA and JR?

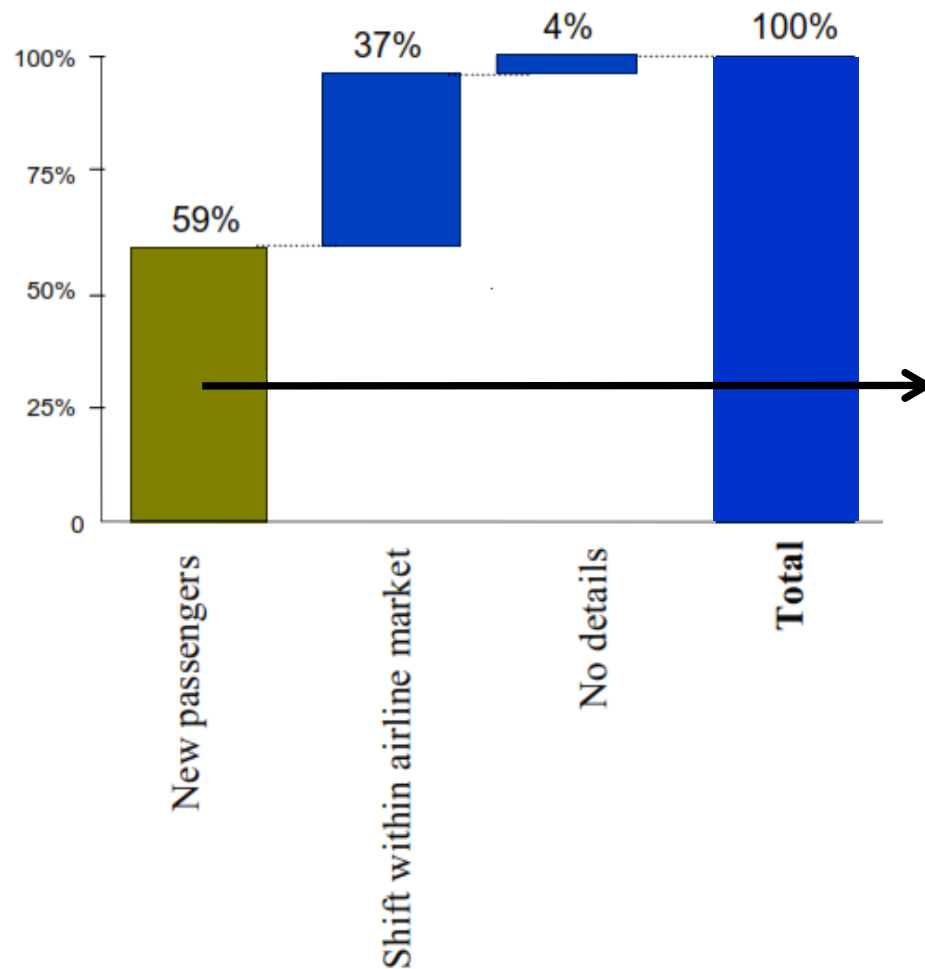
Source: 交通政策基本計画（2015年）

# Introduction

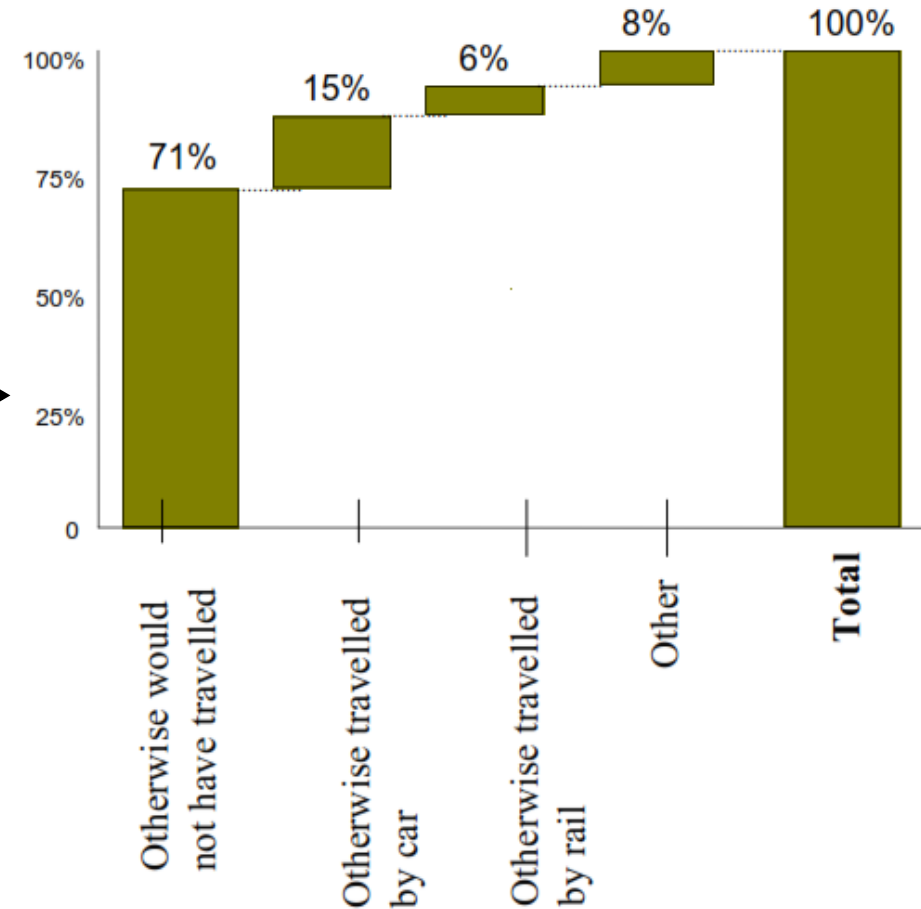
## LCC – FSC – HSR Competition

格安航空、フルサービス航空、高速鉄道の競争

### Classification of low cost passengers



### Classification of 'new' passengers



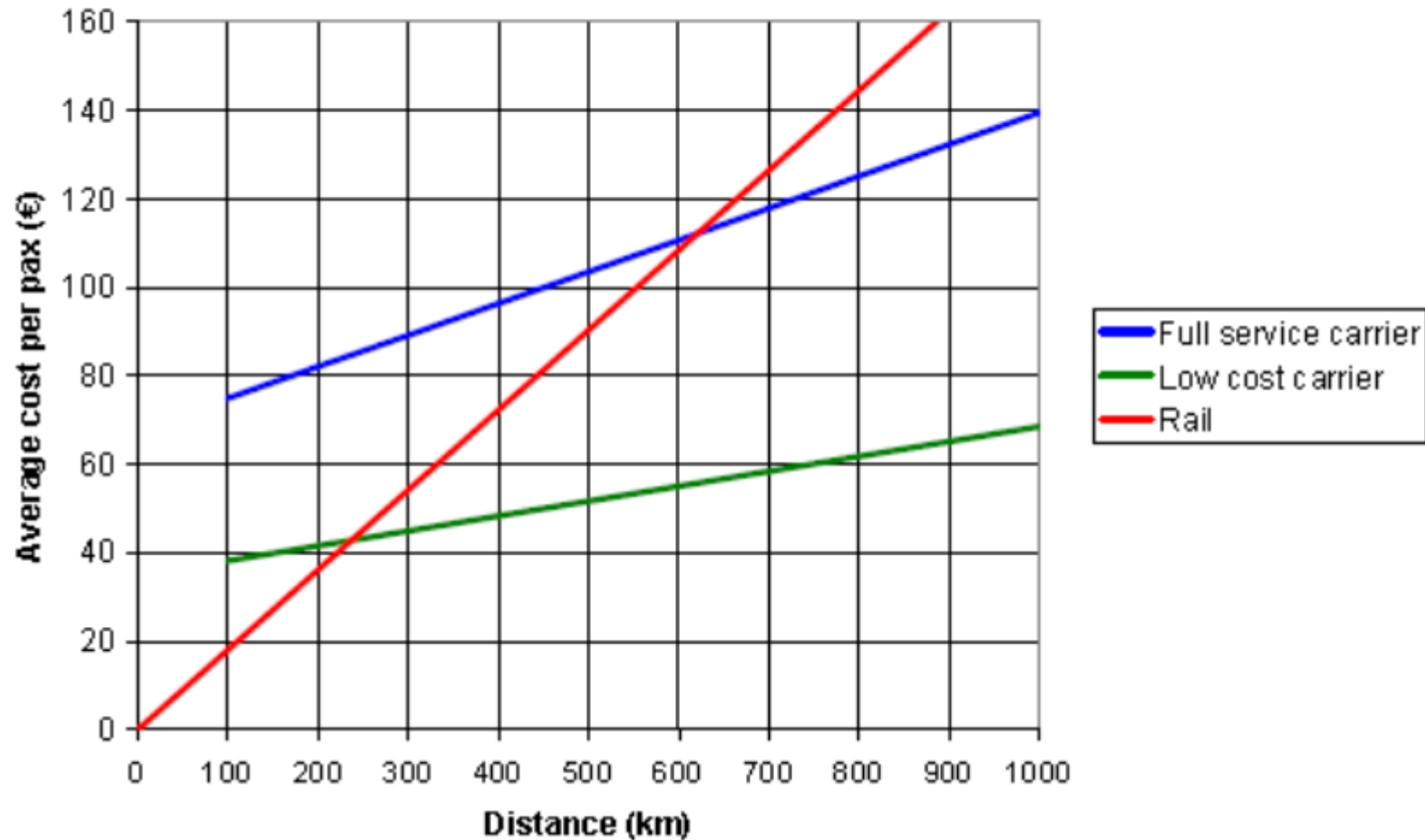
Source: NFO Intratest, 2002: Monitor Group Analysis, Hapaq Lloyd, The Future of Air Travel conference, London, 8-9 November 2004

# Introduction

## LCC – FSC – HSR Competition

格安航空とフルサービス航空と高速鉄道の競争

### HSR and air costs per passenger, by route length

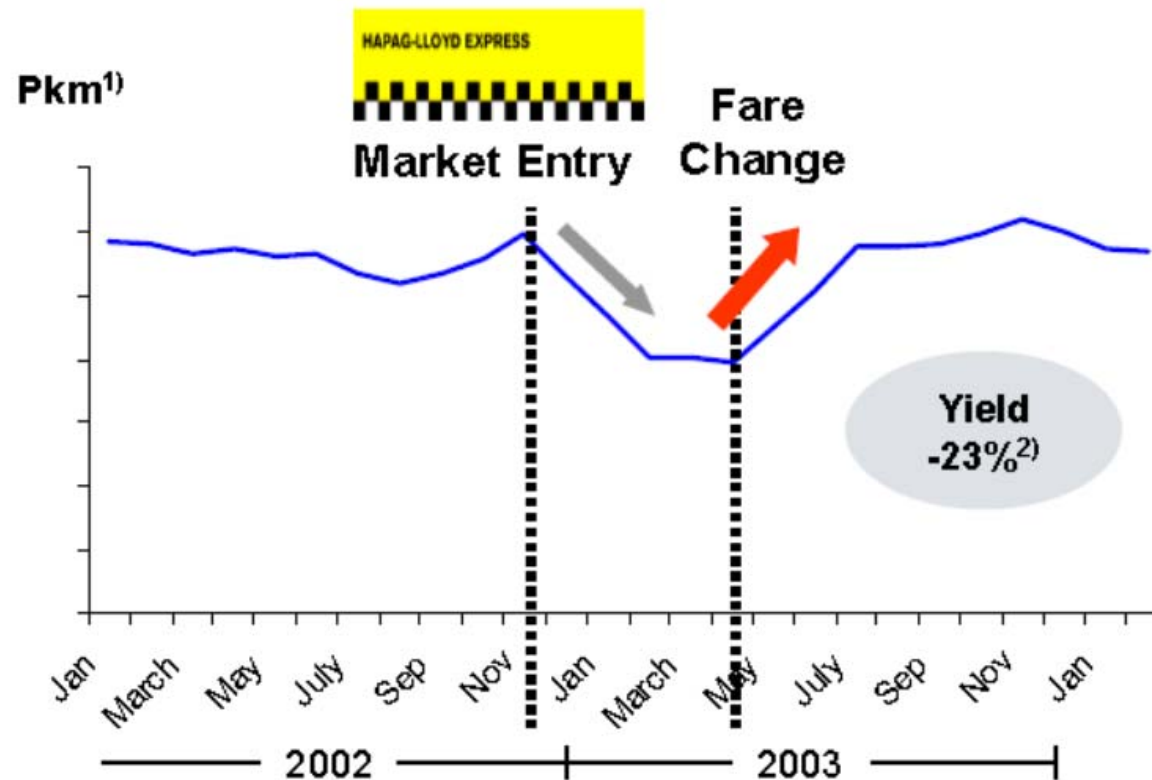


Source: HSR vs LCC: competing or complementary modes?, Stephen Perkins, 2014

# Introduction

## LCC – HSR Competition 格安航空と高速鉄道の競争（ドイツの事例）

### Impact of LCC entry on DB Cologne-Hamburg



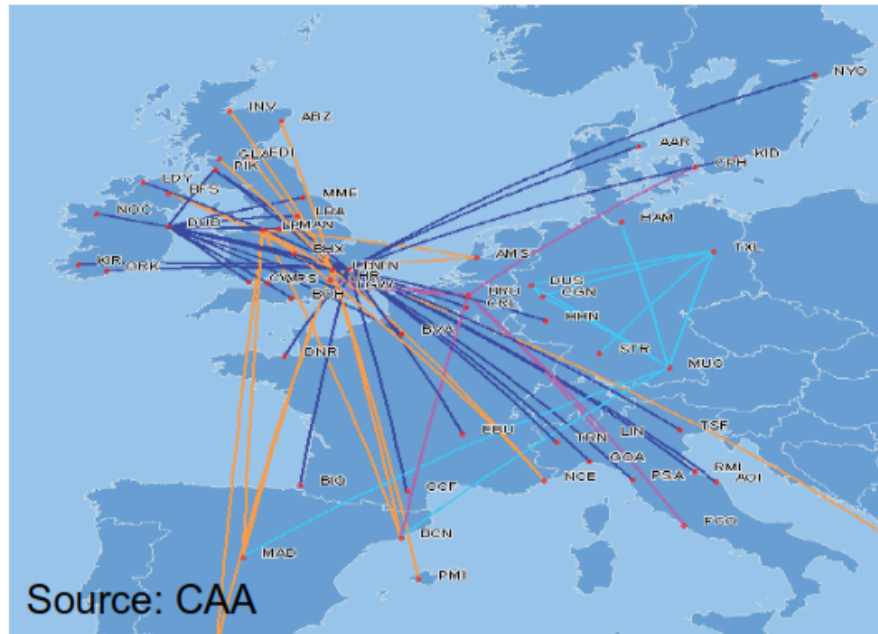
Source: The Functioning of Inter-modal Competition in the Transportation Market: Evidence from the Entry of Low-cost Airlines in Germany  
Friebel and Nifka, 2005

# Introduction

## LCC – FSC Competition

格安航空とフルサービス航空の競争（欧州）

### Low Cost Routes 2000



### Low Cost Routes 2006



- LCC seem harmless at first, but they can be destructive for FSC on longer term.

Source: The Business of Low Cost Carriers and Their Impact on the Industry, Dr Frankie O'Connell, October 2008

- LCC development in Japan started late but now it is growing fast.
- LCCs are good for people but adversely affect FSCs and HSR.
- It is important to measure these benefits and costs.
- Therefore, in this study I intend to **propose a framework to analyze LCC growth benefits for people and costs to other operators.**



- What happens if LCCs reach **15%** domestic market share?
- What happens if LCCs reach **25%** domestic market share?
- How much benefit will people gain?
- How much revenue will be lost for FSC and HSR?
- How **to manage** rapid increase of LCC share?

### LCC Growth Scenarios

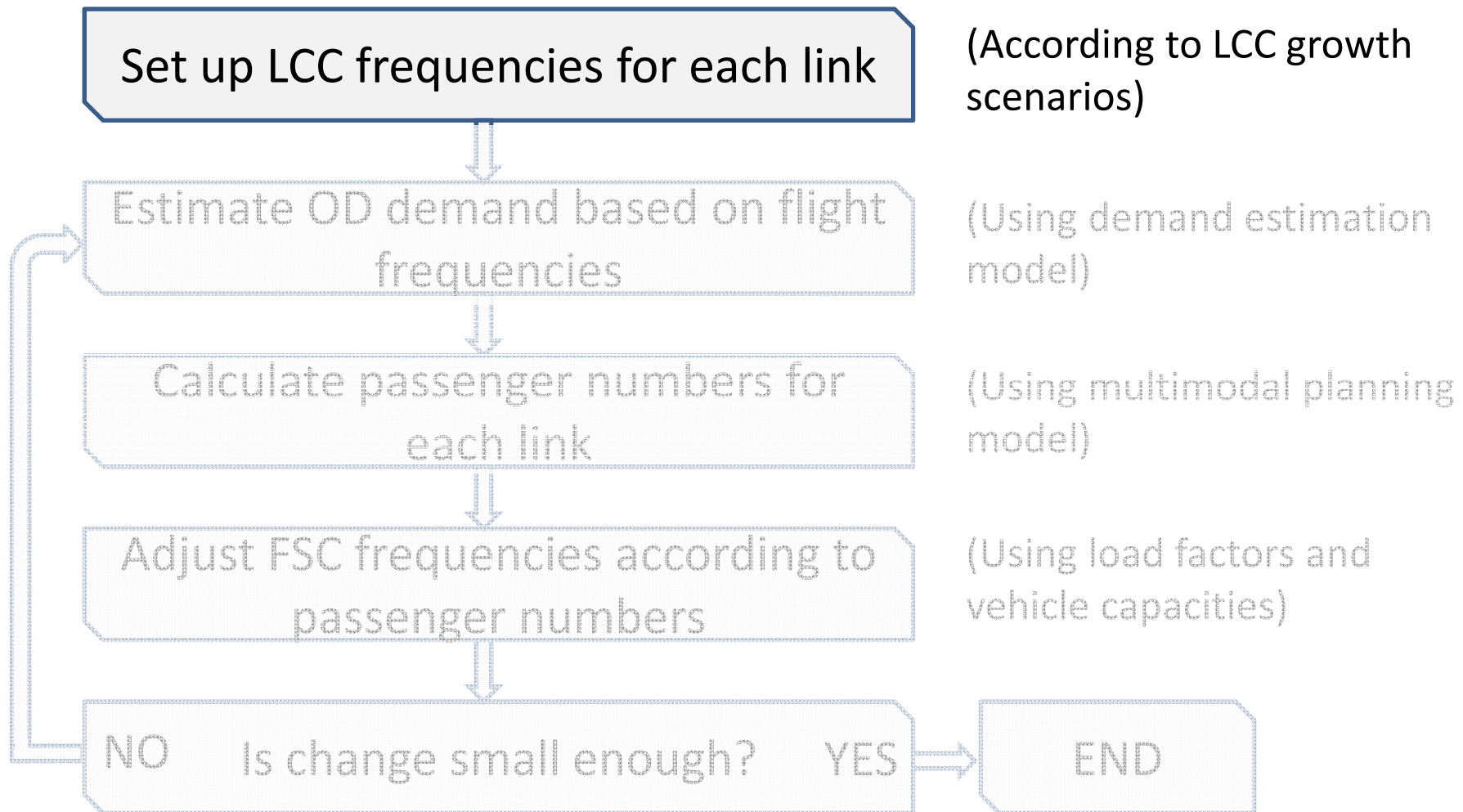
- Exogenously increase LCC flight numbers to match 15% (25%) market share

### Network Simulation

- Estimate new OD demand (trip generation/distribution)
- Distribute demand to lines (route choice/mode choice)

### Network Analysis

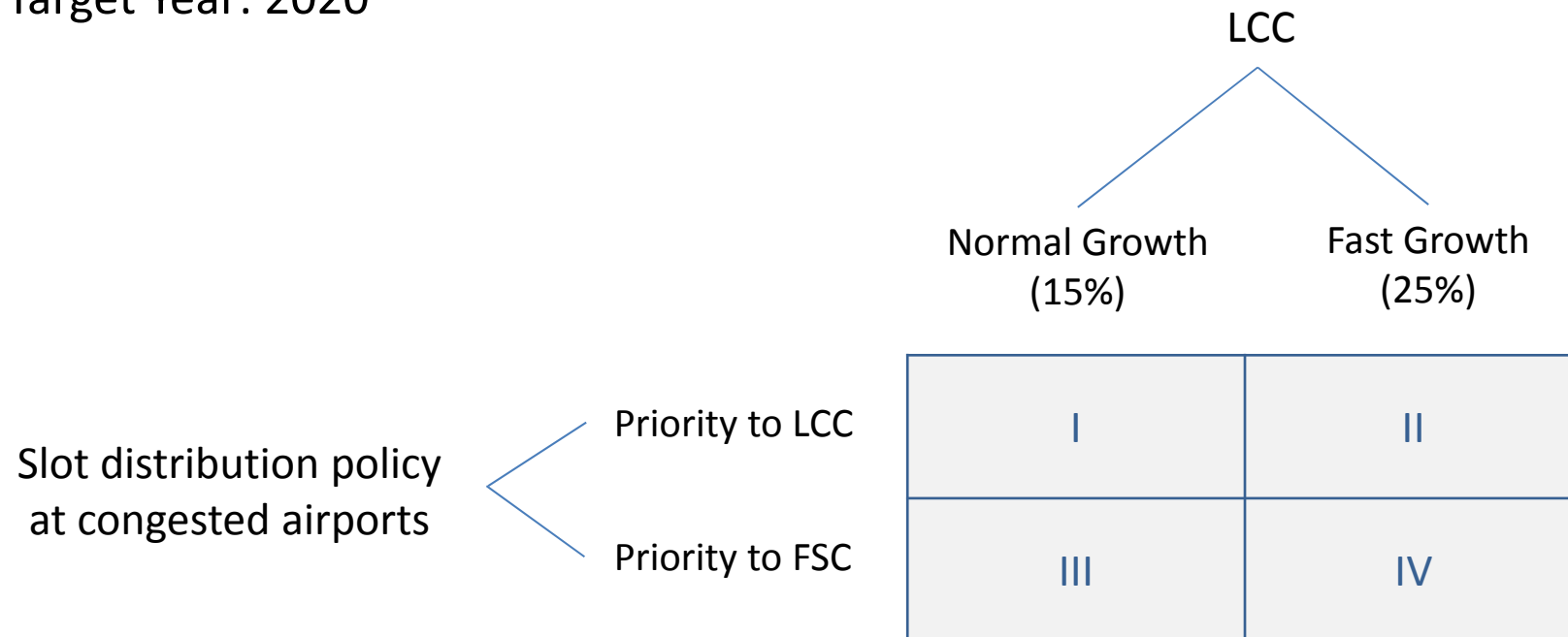
- Calculate and compare users` benefits (total travel time, total users cost), operators` loss (cost and revenue).



- 20 prefectures as zones,
- 23 airports with rail connections,
- Shinkansen + Airline network.
- Covers 82% of population and %75 of domestic air traffic



Target Year: 2020



Example:

|           |     | Current (2015) |       |        | 15% (2020) |       |        | 25% (2020) |       |        |
|-----------|-----|----------------|-------|--------|------------|-------|--------|------------|-------|--------|
| 便/日       |     | Narita         | Chubu | Kansai | Narita     | Chubu | Kansai | Narita     | Chubu | Kansai |
| Kagoshima | FSC | 0              | 4     | 0      | 0          | 4     | 0      | 0          | 4     | 0      |
|           | LCC | 2              | 2     | 4      | 4          | 4     | 8      | 6          | 6     | 12     |

- Gravity model below will be used to estimate OD demand:

$$T_{OD}^{NW} = \Lambda (N_1)^\alpha (N_2)^\beta (LOS_{OD})^\gamma$$

$$LOS_{OD} = \sum_m \exp(V_m^m) \quad V_m = \beta_{GC} GC_m + \beta_{m1} c_{m1} + \beta_{m2} c_{m2},$$

$$GC_m = C_m + 0.3T_m \quad T_m = \sum_{i \in m} t_i + \sum_{j \in m} \frac{d_j}{S_j} + \sum_{k \in m} ta_k + w_m + s_m$$

$$w_m = \frac{1}{2} \frac{18}{F_m}$$

$N_1, N_2$ : city populations,  $LOS$ : Service level,  $V_m$ : Utility of mode  $m$ ,  $GC$ : Generalized cost,  $T_m$ : travel time for mode  $m$ ,  $t_i$ : link travel time,  $w_m$ : average waiting time,  $s_m$ : transfer time  $F_m$ : frequency

1) Okumura, M. and Tsukai, M. "Air-Rail Inter-modal Network Design Under Hub Capacity Constraint", Journal of the Eastern Asia Society for Transportation Studies, Vol. 7, 2007

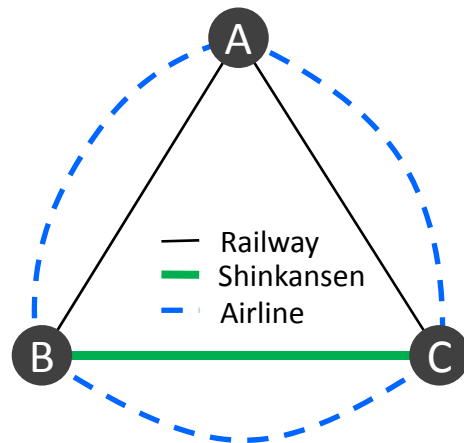
- OD demand is divided based on income levels and travel purpose.
- Numbers will be calculated based on surveys from past studies.

|                |          | Income Level |             |
|----------------|----------|--------------|-------------|
|                |          | Low Income   | High Income |
| Travel Purpose | Business | I            | II          |
|                | Leisure  | III          | IV          |



# Methodology Network Planning Model ネットワーク・プランニング・モデル

INPUT:



OD Demand

|   | A  | B  | C  |
|---|----|----|----|
| A | -  | 60 | 60 |
| B | 60 | -  | 60 |
| C | 60 | 60 | -  |

Time Value: 2

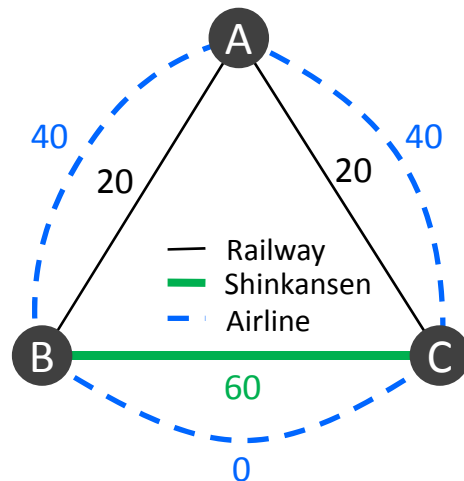
Parameters

|            | Fare | Time | Capacity |
|------------|------|------|----------|
| Rail       | 15   | 30   | 40       |
| Shinkansen | 20   | 20   | 100      |
| Air        | 30   | 20   | 40       |

OBJECTIVE  
FUNCTION:

Minimize Total Generalized Cost (travel time\*time value + fare)

OUTPUT:



# Methodology Network Planning Model ネットワーク・プランニング・モデル

## Objective Function

$$\text{minimize } \mathbf{GC} = v * \left[ \underbrace{\left( \sum_i \sum_j \sum_m t_{ij}^m \sum_k X_{ij}^{km} \right)}_{\text{travel time}} + \underbrace{\left( \sum_n \sum_m \sum_{m'} \tau_n^{mm'} \sum_k Y_n^{kmm'} \right)}_{\text{transfer time}} \right] + \underbrace{\left( \sum_i \sum_j \sum_m f_{ij}^m \sum_k X_{ij}^{km} \right)}_{\text{fare}}$$

Generalized Cost

## Variables and Parameters:

- $X_{ij}^{km}$  : Traffic amount on a link  $ij$  originated from node  $k$  by mode  $m$ ,  
 $Y_n^{kmm'}$  : Transit passengers between mode  $m$  to  $m'$  at node  $n$ , originated from node  $k$   
 $A_n^{km}, B_k^m$  : Ended trips and originated trips at node  $k$  using mode  $m$   
 $T_{kn}$  : OD demand between  $k$  and  $n$   
 $t_{ij}^m, \tau_n^{mm'}$  : Travel time and transfer time  
 $h^m, g^m$  : Seat capacity and max. operable frequency of mode  $m$   
 $f_{ij}^m$  : Fare  
 $v$  : Value of time

## Constraints:

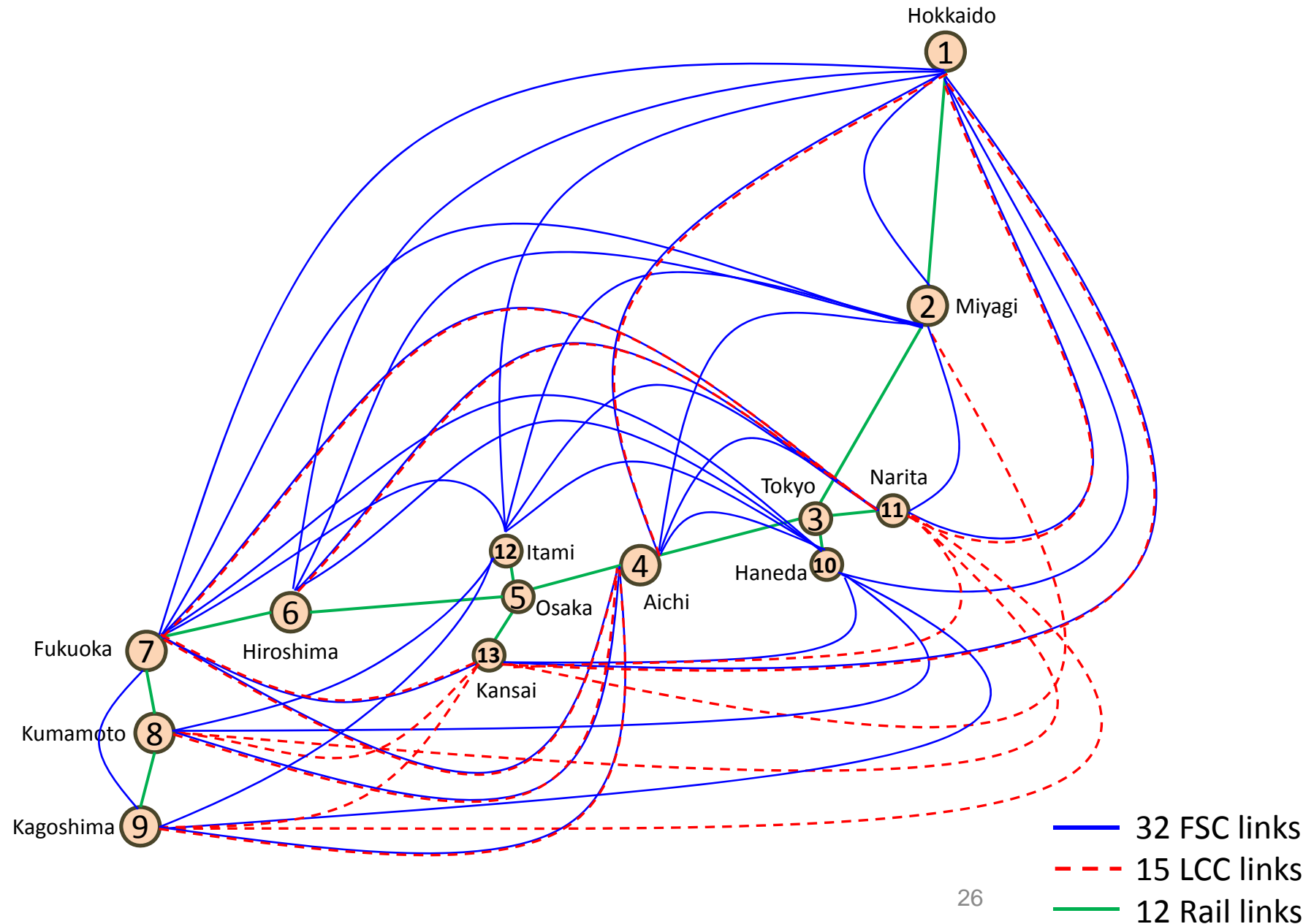
$$\sum_{i \in N^-(n)} X_{in}^{km} = A_n^{km} + \sum_{m' \in M} Y_n^{kmm'} \quad \sum_m A_n^{km} = T_{kn} \quad \sum_k X_{ij}^{km} \leq h^m g^m$$

$$B_n^m + \sum_{m' \in M} Y_n^{km'm} = \sum_{j \in N^+(n)} X_{nj}^{km} \quad \sum_{l \in K} T_{nl} = \sum_{m \in M} B_n^m$$

- Benefit to users: avg. travel time, avg. travel cost
- Cost to operators: operators' revenue loss
- Network efficiency: unit cost of travel

$$\text{Network Efficiency} = \frac{\text{Total Cost of Travel}}{\text{Total Passenger-km}} = \frac{\text{Users' time cost} + \text{Operators' cost}}{\text{Total Passenger-km}}$$

# A Simplified Example Small Scale Network 小規模ネットワーク



- OD demand is fixed and same as year 2010.
- Users are **not** divided by travel purpose or income.
- Value of time is assumed as 25¥/min.
- No capacity limitation at airports.
- Load factors are assumed as : %65 for FSC, %80 for LCC and %65 for HSR

- Seat numbers are assumed as: **350** for FSC, **150** for LCC and **1000** for HSR, (390 for Kyushu trains)
- CO<sub>2</sub> coefficients (g/pax-km): **144** for FSC, **112** for LCC, **12.3** for HSR
- Operating costs are assumed as follows:
  - For FSC: **200**seats X ticket fare per flight
  - For LCC: **110**seats X ticket fare per flight
  - For HSR: **600**seats X ticket fare per service (230 for Kyushu trains)

# A Simplified Example

## Results

## 計算結果

| Link               | Frequencies (Provided) |     |     | Passengers |        |        | Frequencies (Adjusted) |     |     |
|--------------------|------------------------|-----|-----|------------|--------|--------|------------------------|-----|-----|
|                    | Base                   | 15% | 25% | Base       | 15%    | 25%    | Base                   | 15% | 25% |
| Hokkaido-Miyagi    | 35                     | 35  | 35  | 1,083      | 934    | 934    | 2                      | 2   | 2   |
| Hokkaido-Miyagi    | 15                     | 15  | 15  | 0          | 0      | 0      | 0                      | 0   | 0   |
| Hokkaido-Aichi     | 15                     | 15  | 15  | 1,458      | 1,218  | 978    | 7                      | 6   | 5   |
| Hokkaido-Aichi     | 2                      | 4   | 6   | 240        | 480    | 720    | 2                      | 4   | 6   |
| Hokkaido-Hiroshima | 2                      | 2   | 2   | 331        | 331    | 331    | 2                      | 2   | 2   |
| Hokkaido-Fukuoka   | 5                      | 5   | 5   | 890        | 890    | 890    | 4                      | 4   | 4   |
| Hokkaido-Haneda    | 56                     | 56  | 56  | 12,740     | 10,969 | 9,049  | 56                     | 49  | 40  |
| Hokkaido-Narita    | 3                      | 3   | 3   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Hokkaido-Narita    | 16                     | 32  | 48  | 1,920      | 3,840  | 5,760  | 16                     | 32  | 48  |
| Hokkaido-Itami     | 15                     | 15  | 15  | 2,576      | 1,616  | 656    | 12                     | 8   | 3   |
| Hokkaido-Kansai    | 7                      | 7   | 7   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Hokkaido-Kansai    | 8                      | 16  | 24  | 960        | 1,920  | 2,880  | 8                      | 16  | 24  |
| Miyagi-Tokyo       | 103                    | 103 | 103 | 13,192     | 13,043 | 13,043 | 21                     | 21  | 21  |
| Miyagi-Aichi       | 7                      | 7   | 7   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Miyagi-Hiroshima   | 2                      | 2   | 2   | 201        | 201    | 201    | 1                      | 1   | 1   |
| Miyagi-Fukuoka     | 6                      | 6   | 6   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Miyagi-Narita      | 2                      | 2   | 2   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Miyagi-Itami       | 16                     | 16  | 16  | 1,093      | 613    | 133    | 5                      | 3   | 1   |
| Miyagi-Kansai      | 4                      | 8   | 12  | 480        | 960    | 1,440  | 4                      | 8   | 12  |
| Tokyo-Aichi        | 219                    | 219 | 219 | 84,877     | 82,477 | 80,077 | 131                    | 127 | 124 |
| Aichi-Osaka        | 209                    | 209 | 209 | 74,230     | 71,861 | 69,701 | 115                    | 111 | 108 |
| Aichi-Fukuoka      | 10                     | 10  | 10  | 2,275      | 2,162  | 1,922  | 10                     | 10  | 9   |
| Aichi-Fukuoka      | 2                      | 4   | 6   | 240        | 480    | 720    | 2                      | 4   | 6   |
| Aichi-Kumamoto     | 3                      | 3   | 3   | 682        | 334    | 214    | 3                      | 2   | 1   |
| Aichi-Kumamoto     | 1                      | 2   | 3   | 120        | 240    | 360    | 1                      | 2   | 3   |
| Aichi-Kagoshima    | 4                      | 4   | 4   | 108        | 0      | 0      | 1                      | 0   | 0   |
| Aichi-Kagoshima    | 2                      | 4   | 6   | 240        | 480    | 720    | 2                      | 4   | 6   |
| Aichi-Haneda       | 3                      | 3   | 3   | 0          | 0      | 0      | 0                      | 0   | 0   |
| Aichi-Narita       | 4                      | 4   | 4   | 0          | 0      | 0      | 0                      | 0   | 0   |
|                    |                        |     |     |            |        |        | Rail                   | FSC | LCC |



# A Simplified Example

## Results

## 計算結果

| Link               | Frequencies (Provided) |     |     | Passengers |         |         | Frequencies (Resulting) |     |     |
|--------------------|------------------------|-----|-----|------------|---------|---------|-------------------------|-----|-----|
|                    | Base                   | 15% | 25% | Base       | 15%     | 25%     | Base                    | 15% | 25% |
| Osaka-Hiroshima    | 124                    | 124 | 124 | 17,741     | 15,701  | 13,661  | 28                      | 25  | 22  |
| Hiroshima-Fukuoka  | 108                    | 108 | 108 | 10,768     | 11,248  | 11,728  | 17                      | 18  | 19  |
| Hiroshima-Haneda   | 17                     | 17  | 17  | 3,867      | 3,867   | 3,867   | 17                      | 17  | 17  |
| Hiroshima-Narita   | 1                      | 1   | 1   | 0          | 0       | 0       | 0                       | 0   | 0   |
| Hiroshima-Narita   | 3                      | 6   | 9   | 360        | 720     | 1,080   | 3                       | 6   | 9   |
| Fukuoka-Kumamoto   | 71                     | 71  | 71  | 8,776      | 8,649   | 8,649   | 35                      | 35  | 35  |
| Fukuoka-Kagoshima  | 2                      | 2   | 2   | 0          | 0       | 0       | 0                       | 0   | 0   |
| Fukuoka-Haneda     | 71                     | 71  | 71  | 16,152     | 16,152  | 16,152  | 71                      | 71  | 71  |
| Fukuoka-Narita     | 3                      | 3   | 3   | 0          | 0       | 0       | 0                       | 0   | 0   |
| Fukuoka-Narita     | 9                      | 18  | 27  | 1,080      | 2,160   | 3,240   | 9                       | 18  | 27  |
| Fukuoka-Itami      | 10                     | 10  | 10  | 2,275      | 2,275   | 2,275   | 10                      | 10  | 10  |
| Fukuoka-Kansai     | 1                      | 1   | 1   | 227        | 227     | 227     | 1                       | 1   | 1   |
| Fukuoka-Kansai     | 5                      | 10  | 15  | 600        | 1,200   | 1,800   | 5                       | 10  | 15  |
| Kumamoto-Kagoshima | 48                     | 48  | 48  | 5,702      | 5,601   | 5,601   | 23                      | 23  | 23  |
| Kumamoto-Haneda    | 19                     | 19  | 19  | 2,814      | 2,574   | 2,334   | 13                      | 12  | 11  |
| Kumamoto-Narita    | 2                      | 4   | 6   | 240        | 480     | 720     | 2                       | 4   | 6   |
| Kumamoto-Itami     | 9                      | 9   | 9   | 1,449      | 1,329   | 1,209   | 7                       | 6   | 6   |
| Kumamoto-Kansai    | 1                      | 2   | 3   | 120        | 240     | 360     | 1                       | 2   | 2   |
| Kagoshima-Haneda   | 23                     | 23  | 23  | 3,063      | 2,823   | 2,583   | 14                      | 13  | 12  |
| Kagoshima-Narita   | 2                      | 4   | 6   | 240        | 480     | 720     | 2                       | 4   | 6   |
| Kagoshima-Itami    | 13                     | 13  | 13  | 1,415      | 904     | 184     | 7                       | 4   | 1   |
| Kagoshima-Kansai   | 4                      | 8   | 12  | 480        | 960     | 1,440   | 4                       | 8   | 12  |
| Haneda-Itami       | 40                     | 40  | 40  | 9,100      | 9,100   | 9,100   | 40                      | 40  | 40  |
| Haneda-Kansai      | 11                     | 11  | 11  | 0          | 0       | 0       | 0                       | 0   | 0   |
| Narita-Itami       | 4                      | 4   | 4   | 0          | 0       | 0       | 0                       | 0   | 0   |
| Narita-Kansai      | 8                      | 16  | 24  | 960        | 1,920   | 2,880   | 8                       | 16  | 24  |
| Total              |                        |     |     | 361,636    | 362,008 | 362,608 |                         |     |     |
|                    |                        |     |     |            |         |         | Rail                    | FSC | LCC |

# A Simplified Example

## Results

## 計算結果

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| Hokkaido-Miyagi    | 35                     | 35  | 35  | 1,083      | 934   | 934 | 2                      | 2   | 2   |
| Hokkaido-Miyagi    | 15                     | 15  | 15  | 0          | 0     | 0   | 0                      | 0   | 0   |
| Hokkaido-Aichi     | 15                     | 15  | 15  | 1,458      | 1,218 | 978 | 7                      | 6   | 5   |
| Hokkaido-Aichi     | 2                      | 4   | 6   | 240        | 480   | 720 | 2                      | 4   | 6   |
| Hokkaido-Hiroshima | 2                      | 2   | 2   | 331        | 331   | 331 | 2                      | 2   | 2   |

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|-----------------|------------------------|-----|-----|------------|-------|-----|
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| Hokkaido-Miyagi | 15                     | 15  | 15  | 0          | 0     | 0   |
| Hokkaido-Aichi  | 15                     | 15  | 15  | 1,458      | 1,218 | 978 |
| Hokkaido-Aichi  | 2                      | 4   | 6   | 240        | 480   | 720 |

|                  |     |     |     |        |        |        |     |     |     |
|------------------|-----|-----|-----|--------|--------|--------|-----|-----|-----|
| Miyagi-Hiroshima | 2   | 2   | 2   | 201    | 201    | 201    | 1   | 1   | 1   |
| Miyagi-Fukuoka   | 6   | 6   | 6   | 0      | 0      | 0      | 0   | 0   | 0   |
| Miyagi-Narita    | 2   | 2   | 2   | 0      | 0      | 0      | 0   | 0   | 0   |
| Miyagi-Itami     | 16  | 16  | 16  | 1,093  | 613    | 133    | 5   | 3   | 1   |
| Miyagi-Kansai    | 4   | 8   | 12  | 480    | 960    | 1,440  | 4   | 8   | 12  |
| Tokyo-Aichi      | 219 | 219 | 219 | 84,877 | 82,477 | 80,077 | 131 | 127 | 124 |
| Aichi-Osaka      | 209 | 209 | 209 | 74,230 | 71,861 | 69,701 | 115 | 111 | 108 |
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| Aichi-Kumamoto   | 1   | 2   | 3   | 120    | 240    | 360    | 1   | 2   | 3   |
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| Aichi-Haneda     | 3   | 3   | 3   | 0      | 0      | 0      | 0   | 0   | 0   |
| Aichi-Narita     | 4   | 4   | 4   | 0      | 0      | 0      | 0   | 0   | 0   |

|  |  |  |  |  |  |  |      |     |     |
|--|--|--|--|--|--|--|------|-----|-----|
|  |  |  |  |  |  |  | Rail | FSC | LCC |
|--|--|--|--|--|--|--|------|-----|-----|

# A Simplified Example

## Results

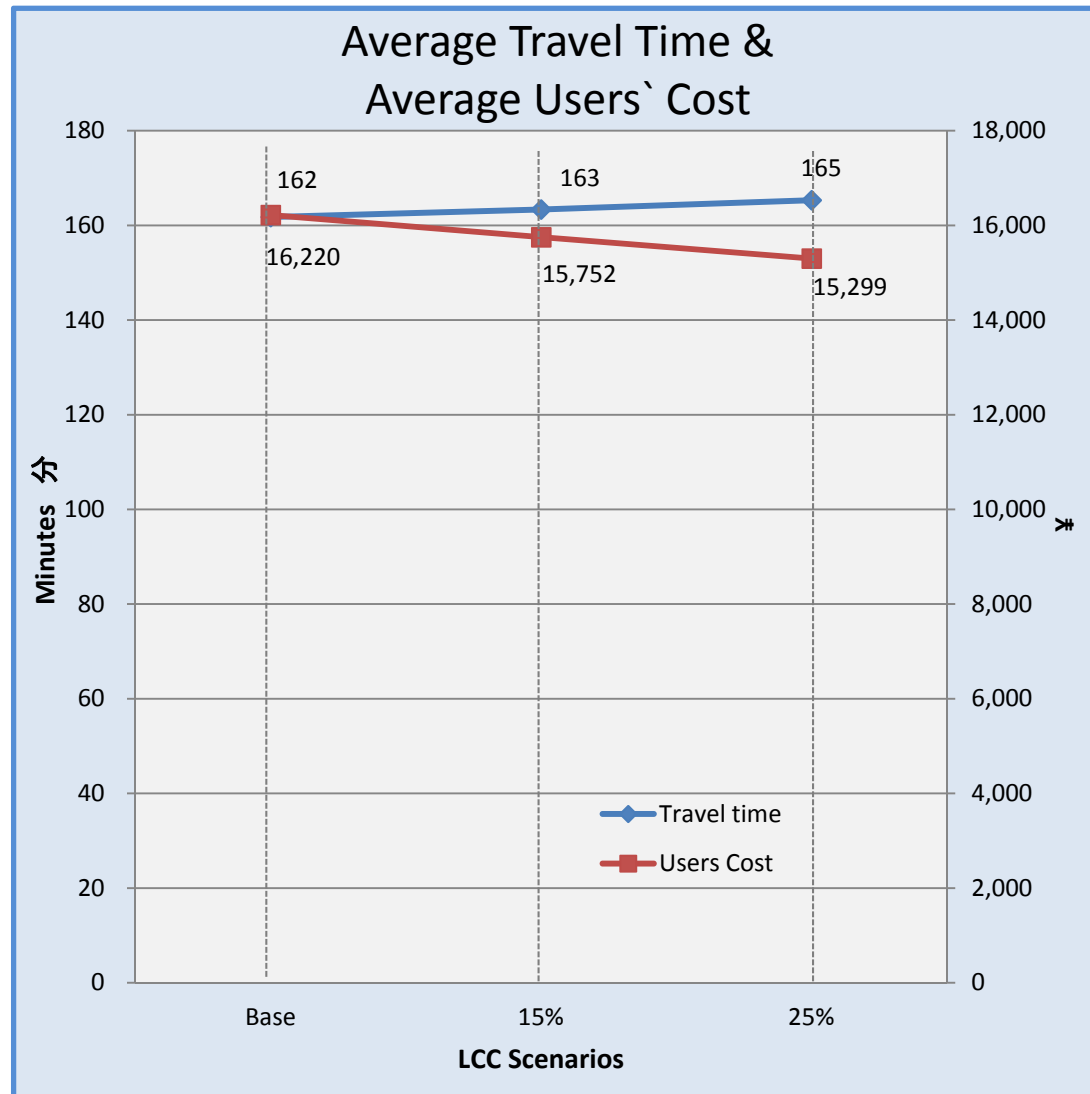
## 計算結果

| Link                    | Frequencies (Provided) |          |          | Passengers |          |          | Frequencies (Resulting) |          |          |
|-------------------------|------------------------|----------|----------|------------|----------|----------|-------------------------|----------|----------|
|                         | Base                   | 15%      | 25%      | Base       | 15%      | 25%      | Base                    | 15%      | 25%      |
| Osaka-Hiroshima         | 124                    | 124      | 124      | 17,741     | 15,701   | 13,661   | 28                      | 25       | 22       |
| Hiroshima-Fukuoka       | 108                    | 108      | 108      | 10,768     | 11,248   | 11,728   | 17                      | 18       | 19       |
| Hiroshima-Haneda        | 17                     | 17       | 17       | 3,867      | 3,867    | 3,867    | 17                      | 17       | 17       |
| Hiroshima-Narita        | 1                      | 1        | 1        | 0          | 0        | 0        | 0                       | 0        | 0        |
| Hiroshima-Narita        | 3                      | 6        | 9        | 360        | 720      | 1,080    | 3                       | 6        | 9        |
| <b>Hiroshima-Narita</b> | <b>1</b>               | <b>1</b> | <b>1</b> | <b>0</b>   | <b>0</b> | <b>0</b> | <b>0</b>                | <b>0</b> | <b>0</b> |
| Fukuoka-Haneda          | 71                     | 71       | 71       | 16,152     | 16,152   | 16,152   | 71                      | 71       | 71       |
| Fukuoka-Narita          | 3                      | 3        | 3        | 0          | 0        | 0        | 0                       | 0        | 0        |
| Fukuoka-Narita          | 9                      | 18       | 27       | 1,080      | 2,160    | 3,240    | 9                       | 18       | 27       |
| Fukuoka-Itami           | 10                     | 10       | 10       | 2,275      | 2,275    | 2,275    | 10                      | 10       | 10       |
| <b>Fukuoka-Narita</b>   | <b>3</b>               | <b>3</b> | <b>3</b> | <b>0</b>   | <b>0</b> | <b>0</b> | <b>0</b>                | <b>0</b> | <b>0</b> |
| Kumamoto-Kagoshima      | 48                     | 48       | 48       | 5,702      | 5,601    | 5,601    | 23                      | 23       | 23       |
| Kumamoto-Haneda         | 19                     | 19       | 19       | 2,814      | 2,574    | 2,334    | 13                      | 12       | 11       |
| Kumamoto-Narita         | 2                      | 4        | 6        | 240        | 480      | 720      | 2                       | 4        | 6        |
| Kumamoto-Itami          | 9                      | 9        | 9        | 1,449      | 1,329    | 1,209    | 7                       | 6        | 6        |
| Kumamoto-Kansai         | 1                      | 2        | 3        | 120        | 240      | 360      | 1                       | 2        | 2        |
| Kagoshima-Haneda        | 23                     | 23       | 23       | 3,063      | 2,823    | 2,583    | 14                      | 13       | 12       |
| Kagoshima-Narita        | 2                      | 4        | 6        | 240        | 480      | 720      | 2                       | 4        | 6        |
| Kagoshima-Itami         | 13                     | 13       | 13       | 1,415      | 904      | 184      | 7                       | 4        | 1        |
| Kagoshima-Kansai        | 4                      | 8        | 12       | 480        | 960      | 1,440    | 4                       | 8        | 12       |
| Haneda-Itami            | 40                     | 40       | 40       | 9,100      | 9,100    | 9,100    | 40                      | 40       | 40       |
| Haneda-Kansai           | 11                     | 11       | 11       | 0          | 0        | 0        | 0                       | 0        | 0        |
| Narita-Itami            | 4                      | 4        | 4        | 0          | 0        | 0        | 0                       | 0        | 0        |
| Narita-Kansai           | 8                      | 16       | 24       | 960        | 1,920    | 2,880    | 8                       | 16       | 24       |
| <b>Narita-Itami</b>     | <b>4</b>               | <b>4</b> | <b>4</b> | <b>0</b>   | <b>0</b> | <b>0</b> | <b>0</b>                | <b>0</b> | <b>0</b> |

# A Simplified Example

## Results

## 計算結果



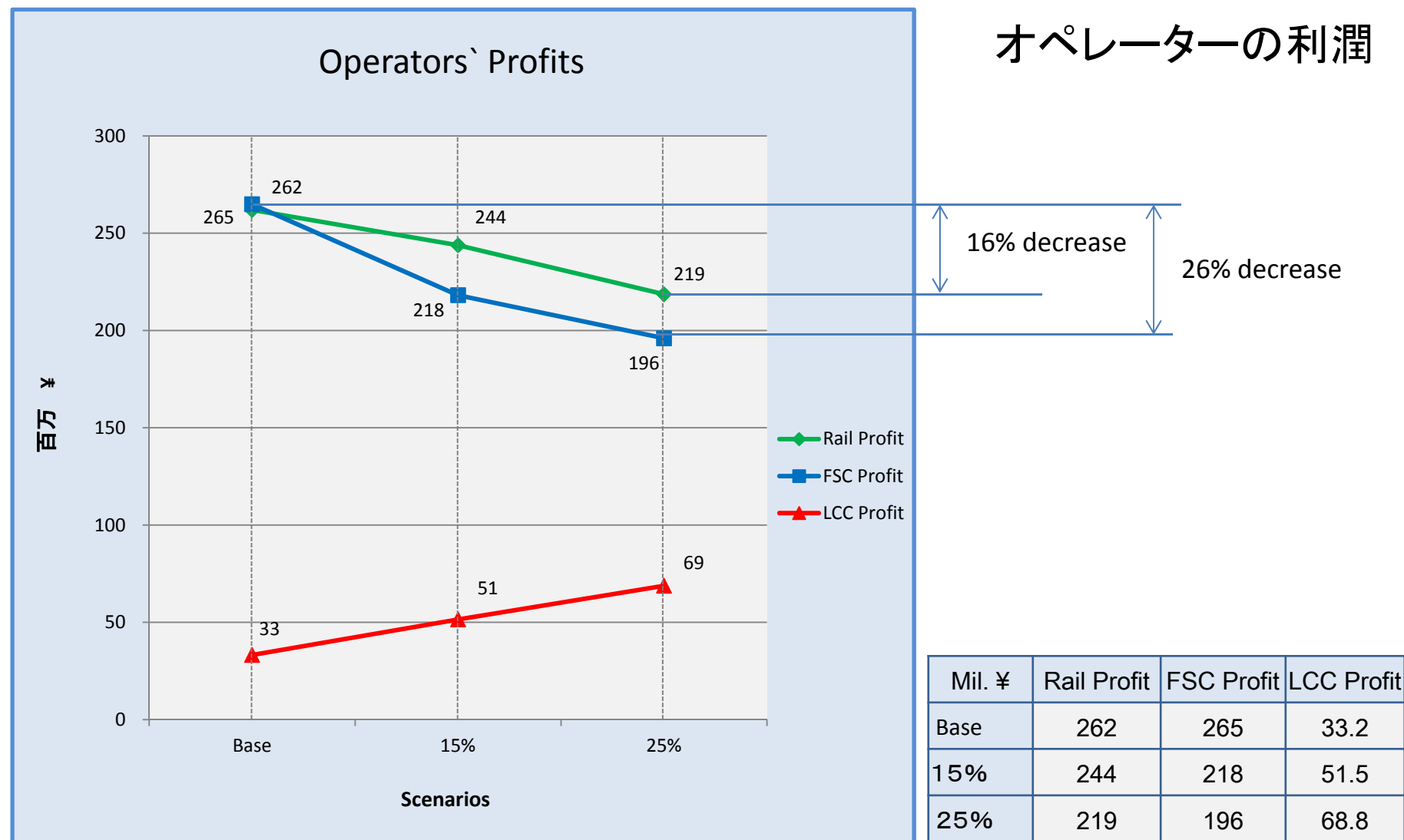
平均所要時間と  
平均ユーザーコストの合計

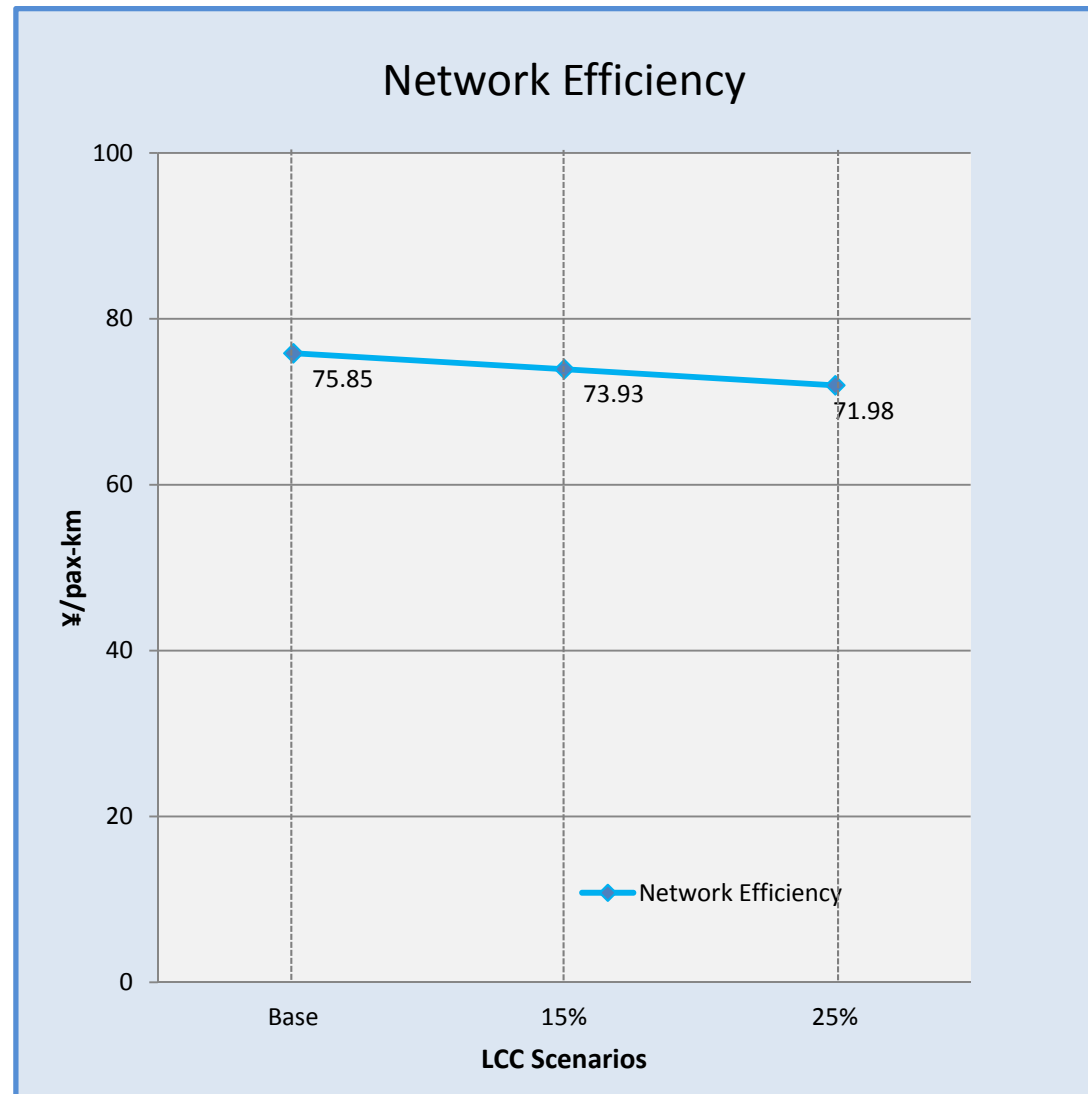
|      | Travel Time<br>Minutes 分 | Users' Cost<br>¥ |
|------|--------------------------|------------------|
| Base | 161.76                   | 16,220.28        |
| 15%  | 163.33                   | 15,751.50        |
| 25%  | 165.30                   | 15,299.09        |

# A Simplified Example

## Results

## 計算結果





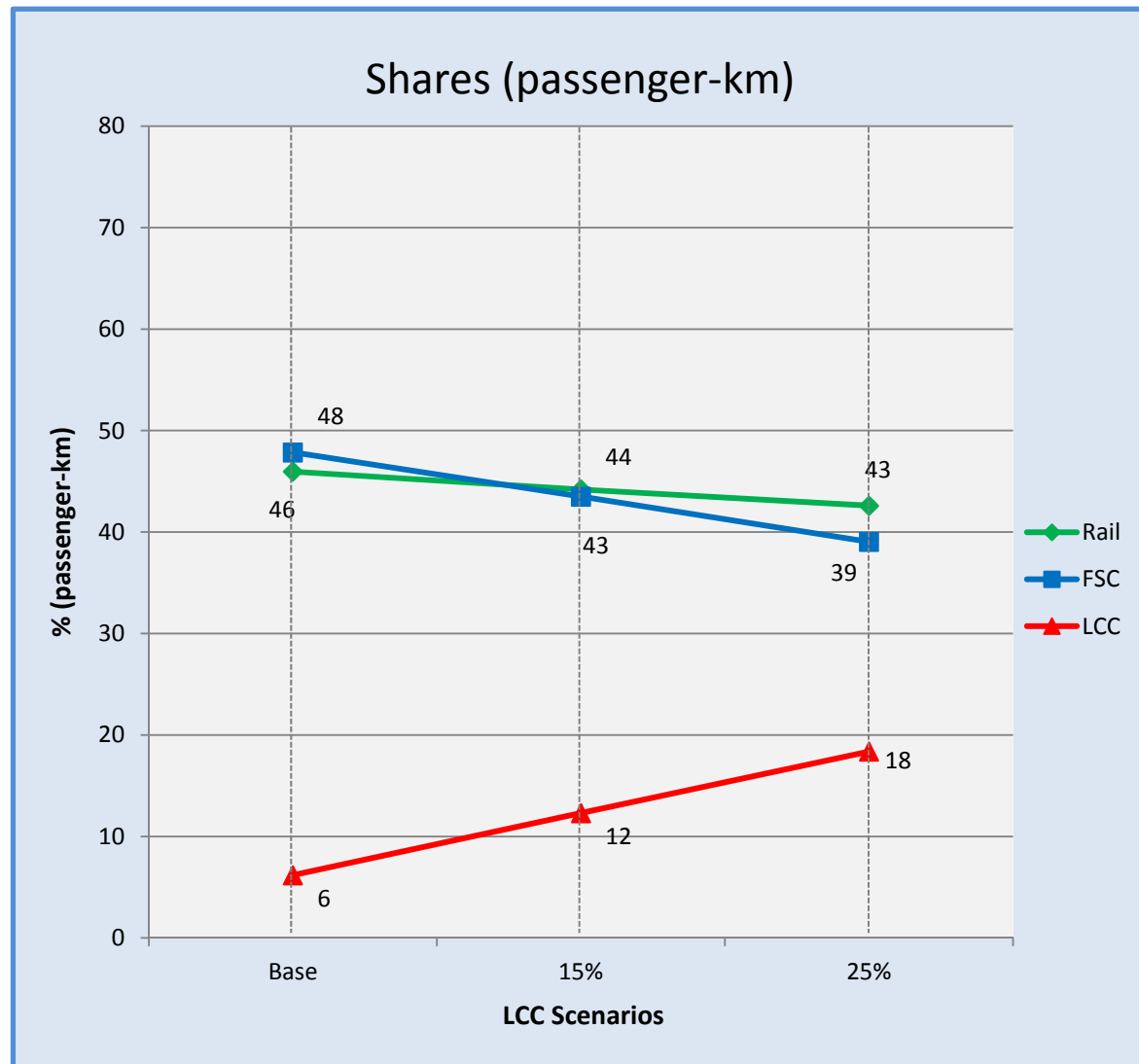
ネットワーク効率性  
(¥/旅客キロ)

|      | Network Efficiency<br>¥ / pax-km |
|------|----------------------------------|
| Base | 75.85                            |
| 15%  | 73.93                            |
| 25%  | 71.98                            |

# A Simplified Example

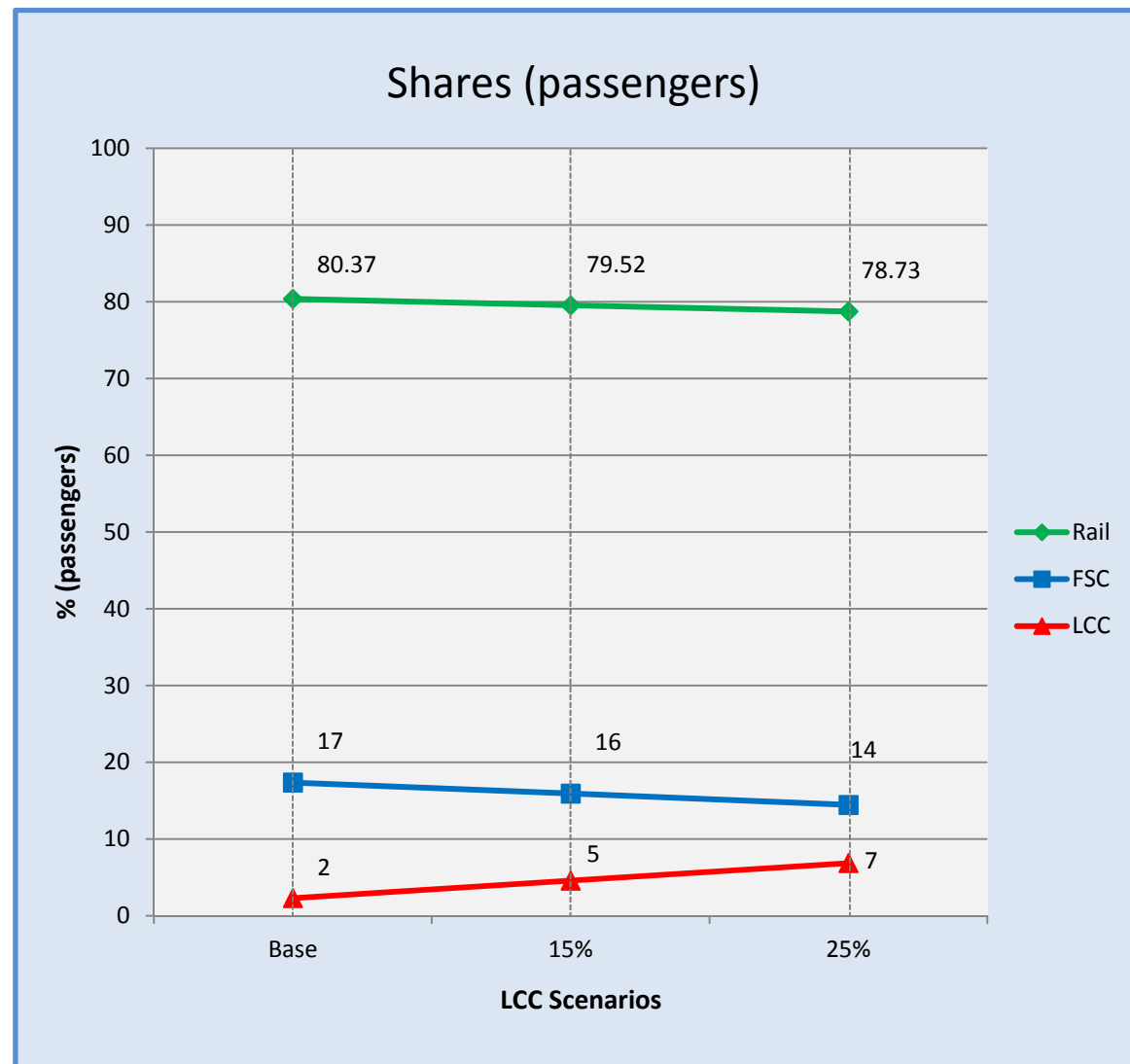
## Results

## 計算結果



## 市場シェア(旅客キロ)

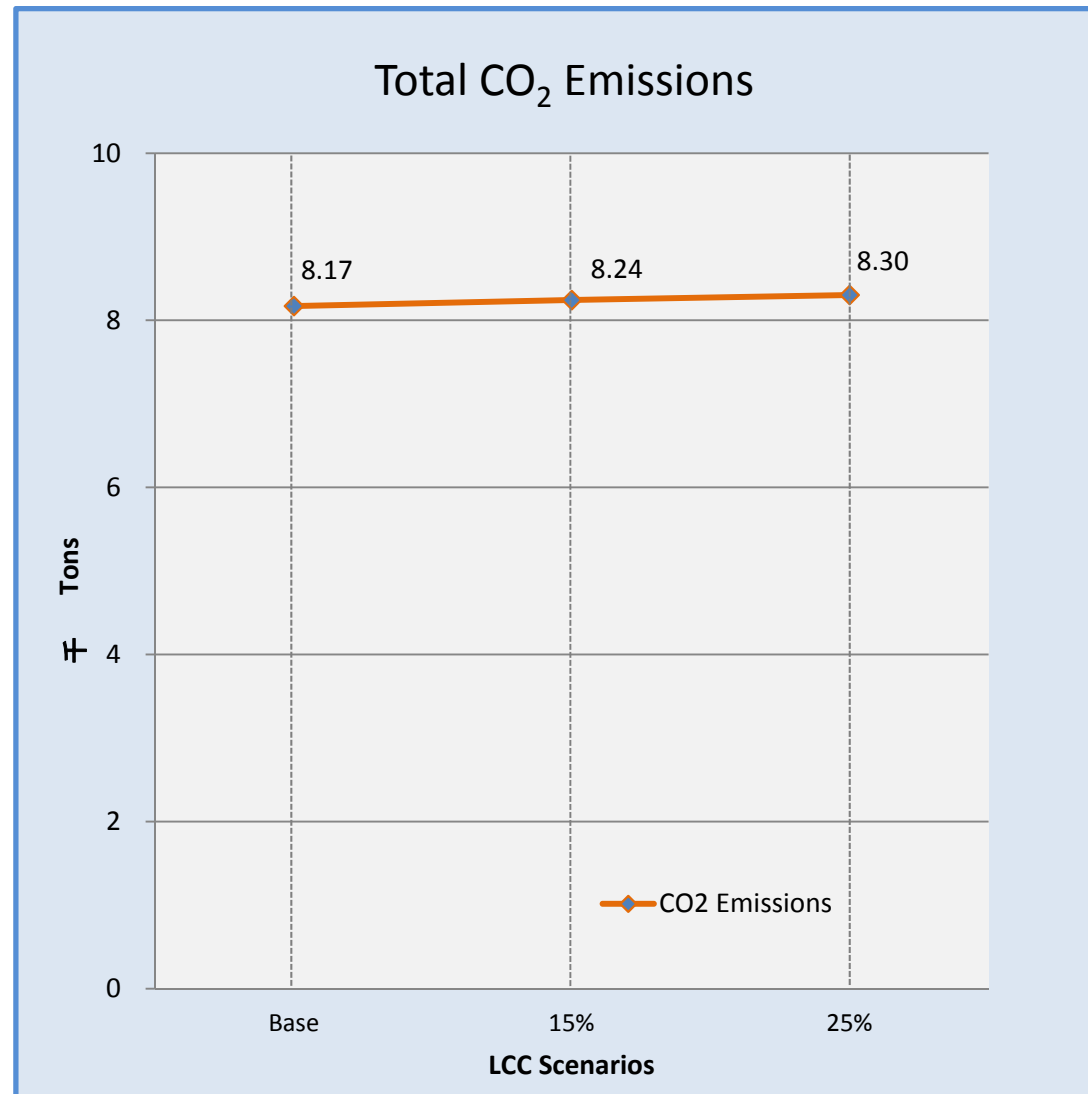
| %    | Rail | FSC  | LCC  |
|------|------|------|------|
| Base | 45.9 | 47.9 | 6.2  |
| 15%  | 44.2 | 43.5 | 12.3 |
| 25%  | 42.6 | 39.0 | 18.4 |



## 市場シェア(旅客数)

| %    | Rail | FSC  | LCC |
|------|------|------|-----|
| Base | 80.3 | 17.3 | 2.4 |
| 15%  | 79.5 | 15.9 | 4.6 |
| 25%  | 78.7 | 14.4 | 6.9 |





CO<sub>2</sub>の総排出量

|      | CO <sub>2</sub> Emissions (Tons) |
|------|----------------------------------|
| Base | 8,169.95                         |
| 15%  | 8,242.06                         |
| 25%  | 8,301.59                         |

- A framework was proposed to measure impact of LCC growth on people, operators and network performance
- This framework can be used to analyze some policy measures (ex. slot distribution policy at congested airports)
- Results might be useful to see negative impact of LCC on FSC and HSR, and positive impact on people.
- Scope can be extended to cover conventional railway and intercity bus in future studies.
- This framework can also be applied easily to other countries

- More detailed analysis for larger network with real data
- Policy recommendations for slot distribution rule at congested airports



ご静聴ありがとうございました