Transit network expansion and accessibility implications:
a case study of Gwangju metropolitan area, South Korea

Thredbo 15

Stockholm, Sweden

Yena Song (Chonnam National University, *Y.Song@chonnam.ac.kr*)

Hyun Kim (University of Tennessee, *hyunkim@utk.edu*)

Keumsook Lee (Sungshin Women's University, *kslee@sungshin.ac.kr*)

Public transportation in a metropolitan area

- Public transportation

: shared passenger transport services available for use by the general public

: crucial element for the development and growth of a metropolitan area

: a social tool that would benefit the disadvantaged groups or minorities

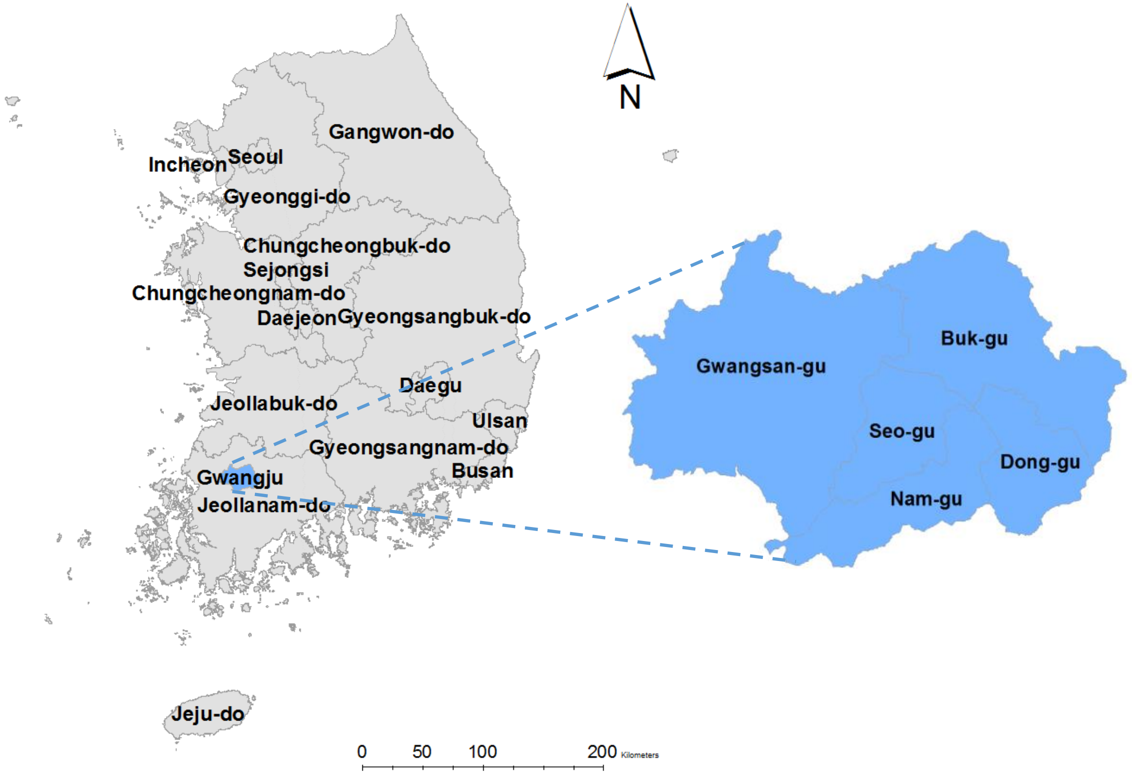
This research

- Focuses on the spatial implications
- Uses the concept of *'accessibility'*
- Does an empirical study in which a major expansion of transit network is planned

How does the provision of further transit network enhance transit accessibility (in the case study area)?

Any spatial variations?

Case study



Population: app. 1.5 millions
Area: app. 500 km^2

2 transit systems in operation

- Local bus
- Subway

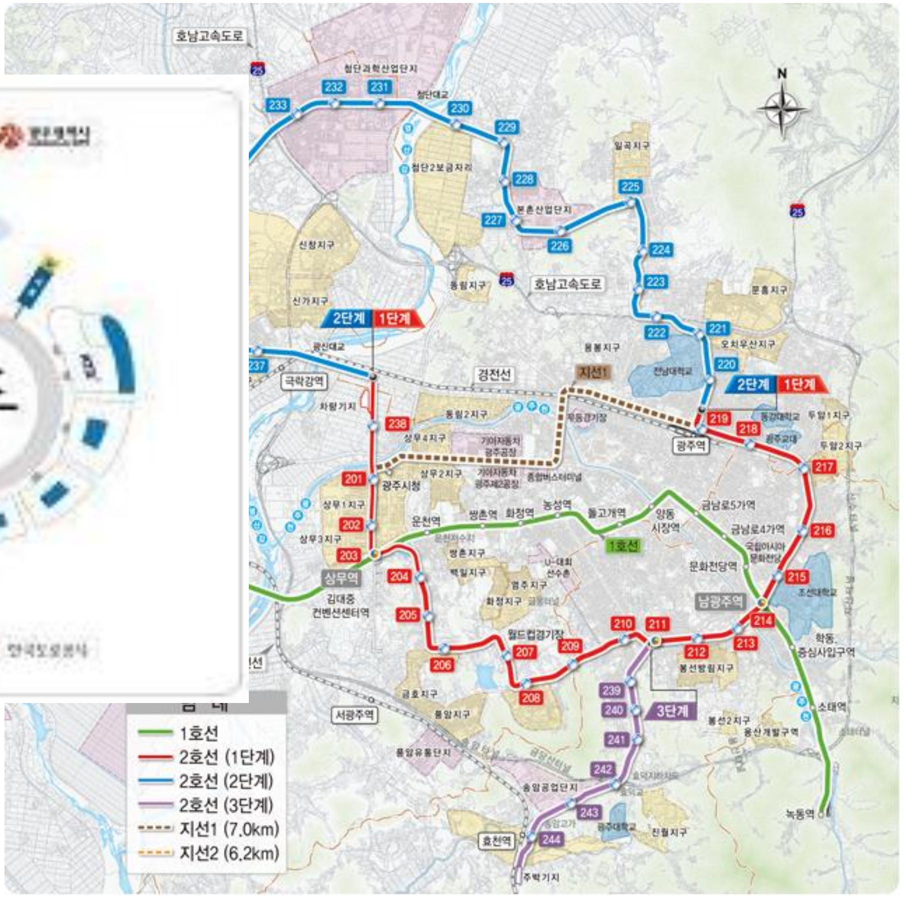
→ With a smart card, transfer between modes or lines can be made for free, i.e. **multi-modal transit system**

Case study

- Bus

+ 'Smart card'

- Subway



Case study

Population and number of automobiles and buses in Gwangju

		1990	2000	2010	2013
Population (thousands)		114.5	137.5	146.8	148.8
Number of cars/vans (thousands)	Total	8.2	33.7	51.8	53.5
	Private	4.8	22.7	40.5	43.6
Buses		825	962	910	930

Modal share in Gwangju

	2008	2010	2012	2015
Private Car	31.3	31.7	36.4	40.3
Taxi	17.6	15.6	15.2	13.8
Bus	38.2	38.0	36.3	35.0
Subway	1.9	2.5	2.7	3.3
Others	10.8	12.2	9.4	7.6

Case study

Current subway systems and modal shares in selected metropolitan areas of Korea (2013)

	Subway		Mode share				
	Operation begins	Total length	Bus	Subway	Private car/van	Taxi	Others
Busan	1985	132 km	25.6	17.1	31.6	13.2	12.5
Deagu	1997	81 km	21.1	7.9	49.4	11.5	10.1
Deajeon	2006	23 km	22.1	3.8	58.9	10.0	5.2
Gwangju	2004	20 km	36.6	2.7	37.9	14.7	8.1
Seoul	1974	332 km	27.4	38.2	23.1	6.9	4.4
Korea		-	25.9	3.0	53.6	10.4	8.0

Quasi-experimental opportunity

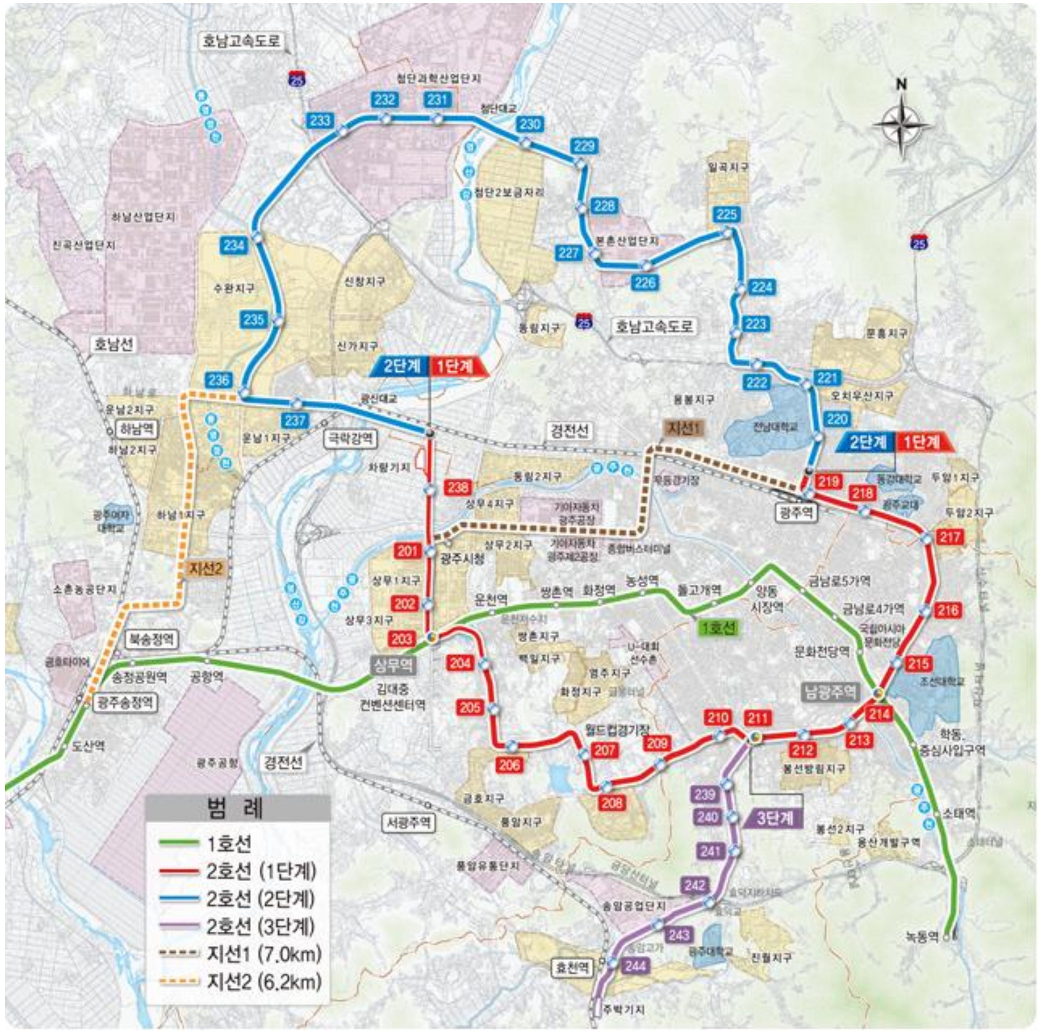
- Expansion of subway network

<u>Original plan of subway construction</u>

- Construction of both Lines 1 and 2 together + Line 3 joins later
- Line 1 as it is + Line 2 stretching north-south

Change of plan due to financial crisis: <u>only Line 1 to go</u>

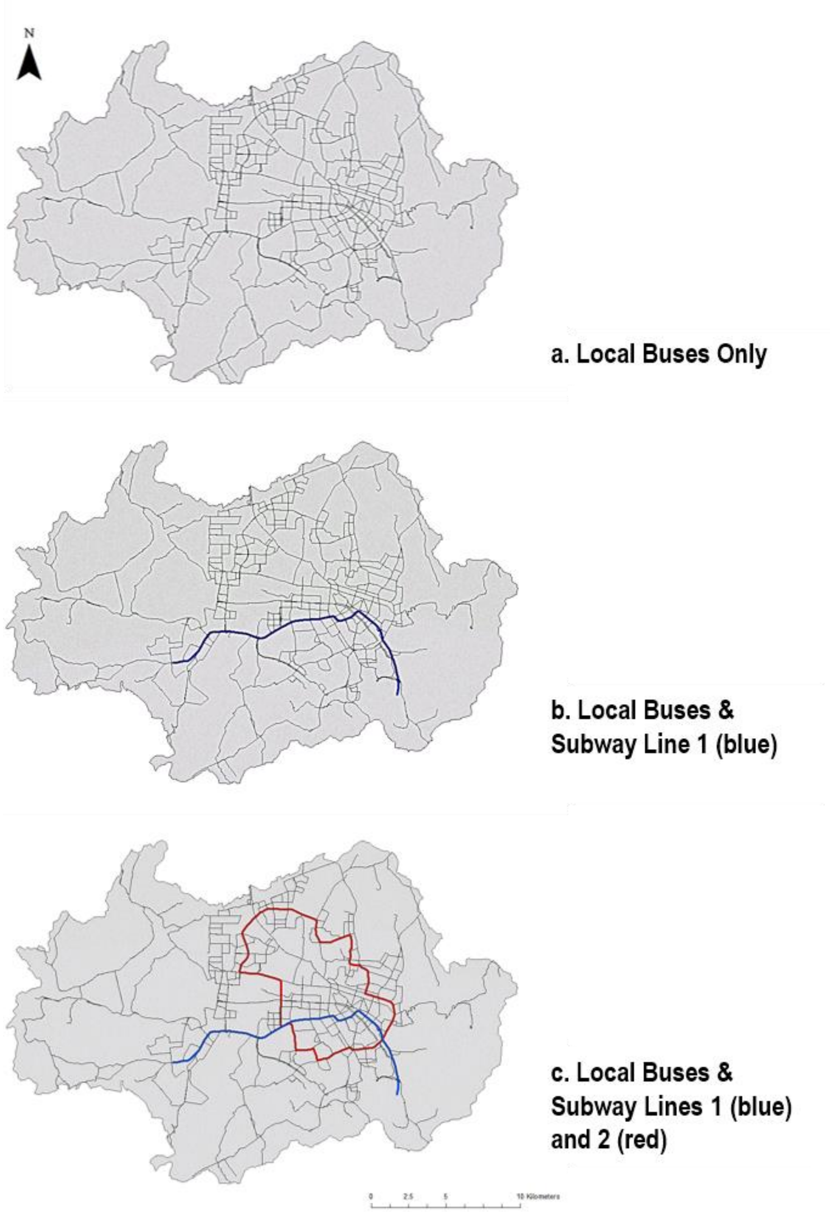
Now new plan emerged and new Line 2 to be implemented soon



Our setting

Three hypothetical stages defined:

1. Local buses only
2. Local buses + subway line 1 (current)
3. Local buses + subway lines 1 & 2 (future scenario)



Our approach: accessibility

- Network accessibility

$$A_i^{node} = k \sum_{j,i \neq j}^{N} \frac{1}{t_{ij}} \qquad A_T \equiv \sum_{i=1}^{N} A_i$$

Where N: number of subway stations and bus stops(N=1~n)

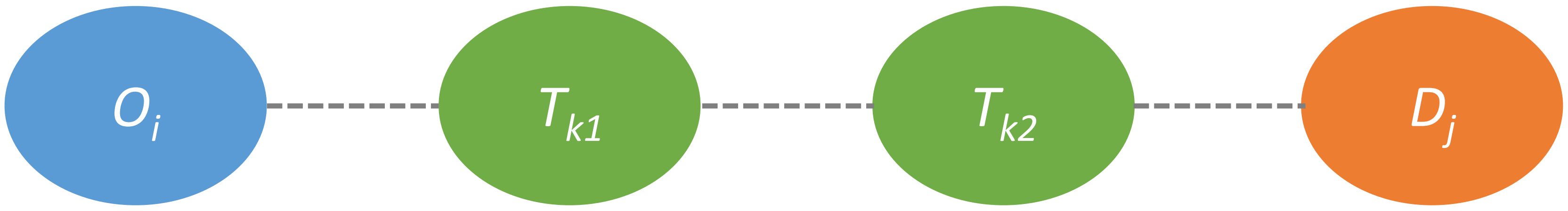
k: scaling constant

t_{ij}: network-based time distance between station i and j

** Time distance: a relevant measure when space is in consideration especially regarding the urban travel behaviour*

Our approach: accessibility

- How do we calculate the time distance between each pair of stations/stops?



Assumptions
- Search boundary for transfer
- Shorter journey, more utility: shortest distance

Our approach: accessibility

- Calculation of time distance

Step 1: route information including the coordinates of stations & stops and average journey time

Step 2: graph construction for all node pairs

Step 3: using the shortest distance journey algorithm the shortest journey time for each node pair calculated

For each transfer, a penalty applied (8 min 3 sec)

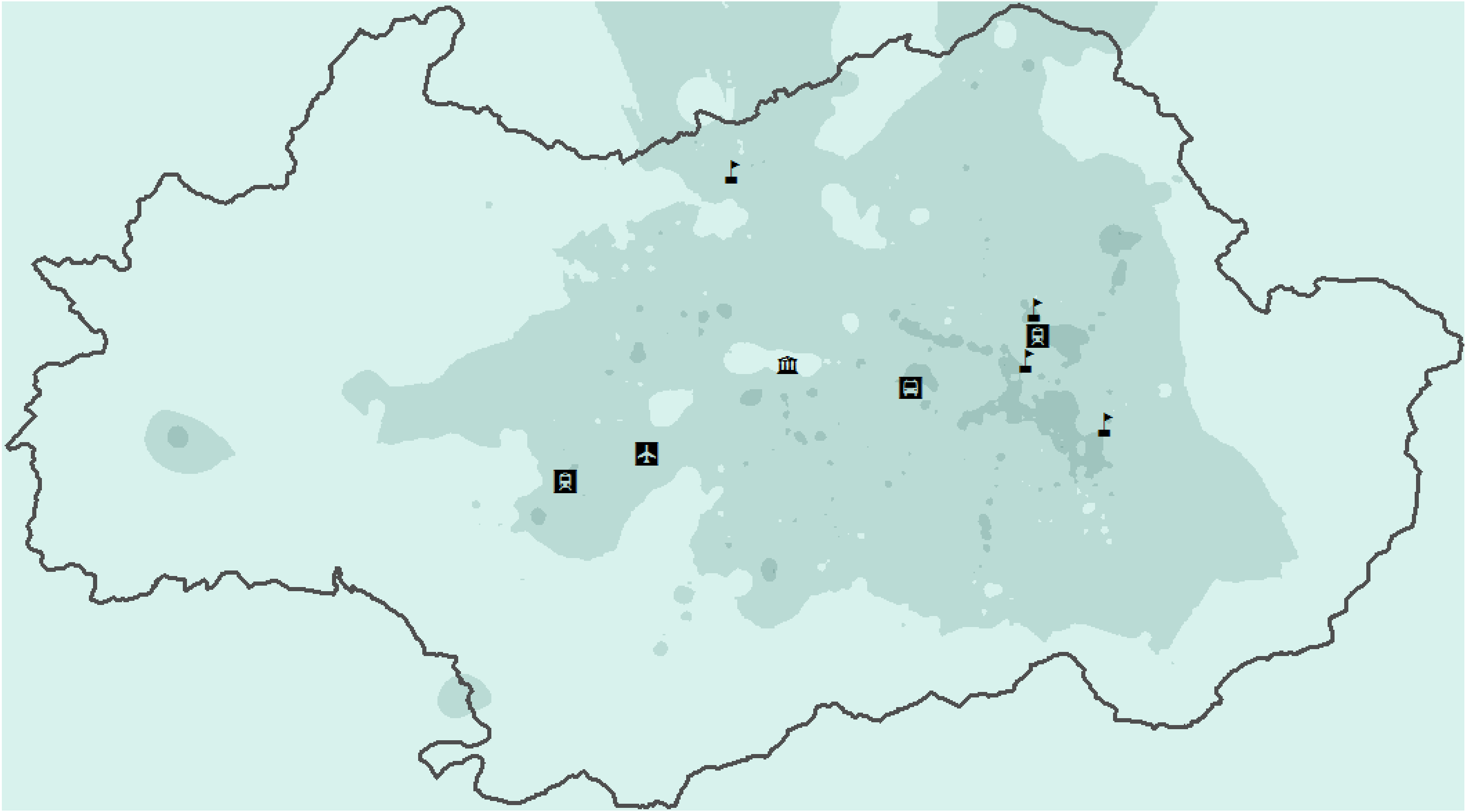
Step 4: node accessibility measured

Results: global accessibility

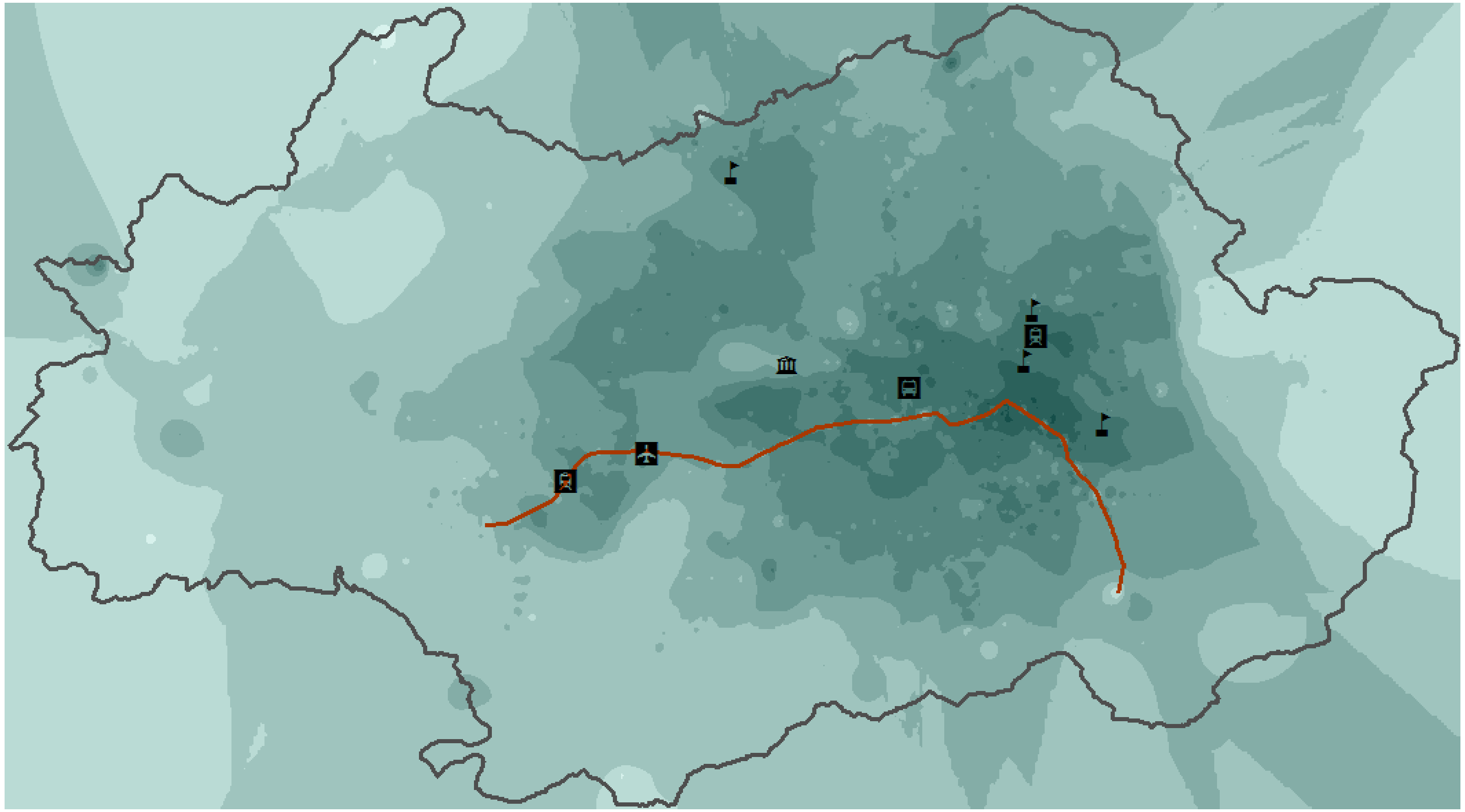
	Av. Acc.*	Av. Acc. Bus	Av. Acc. Subway	Total
Bus only (n=2254)	2.292	2.292	-	5165.81
Bus + Subway line 1 (n=2274)	5.585	5.612	2.495	12699.63
Bus + Subway lines 1 & 2 (n=2318)	5.599	5.685	2.544	12977.67

* Av. Acc.: average accessibility.

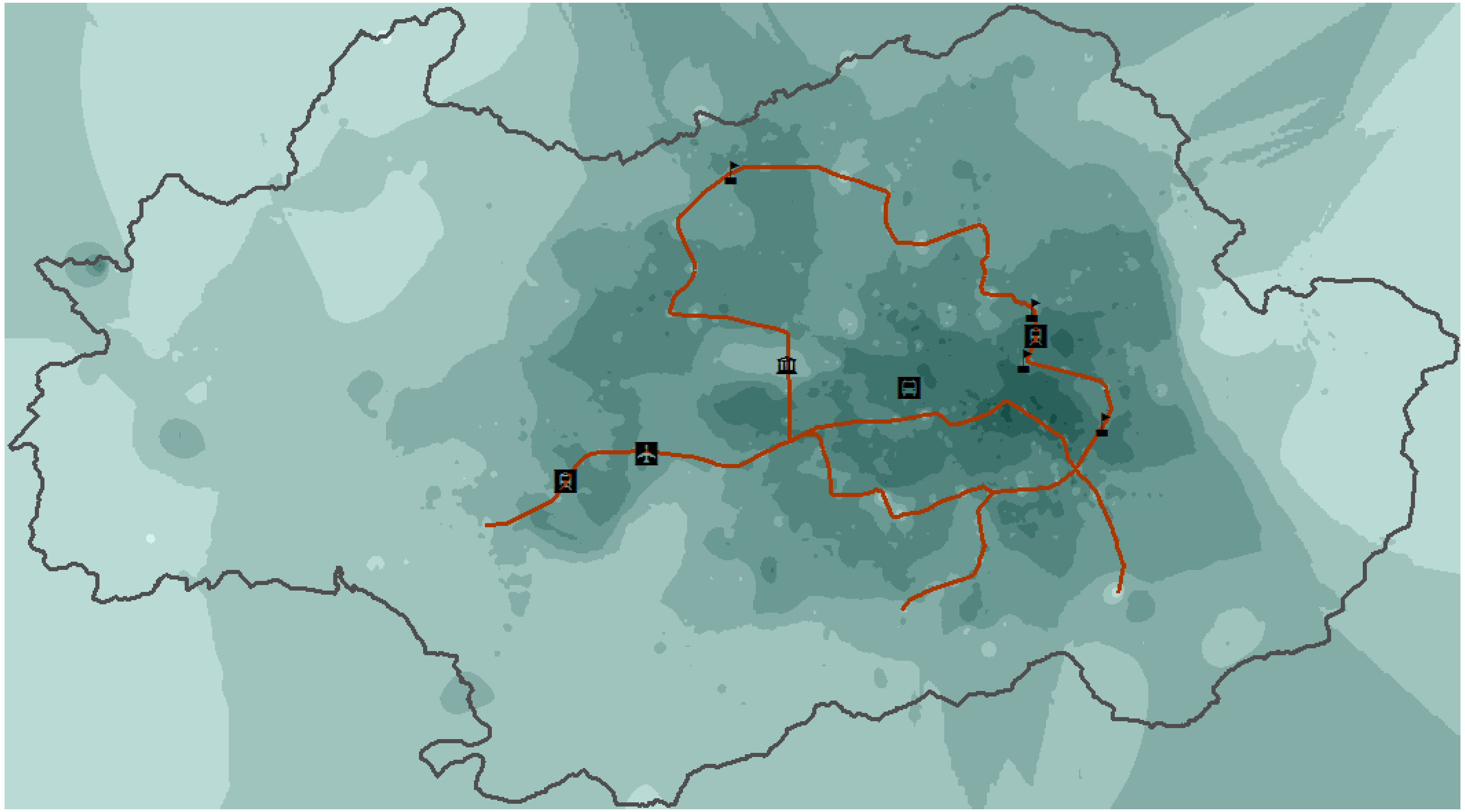
Results: local accessibility



Results: local accessibility



Results: local accessibility



Conclusions & future directions

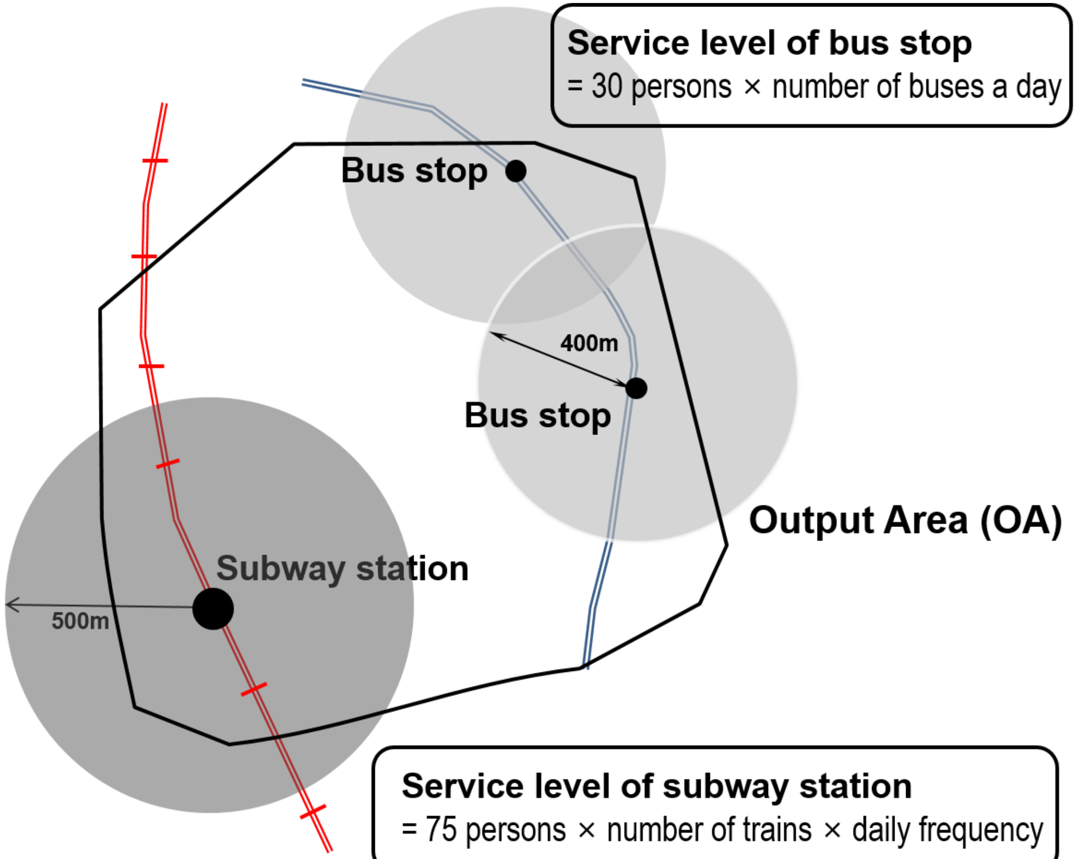
- Conclusions
  - Expansion of transit network is indeed increases accessibility globally and locally
  - The accessibility benefit garnered from the transportation investment does not evenly apply over the space.
  - The current transit system has significantly improved the transit accessibility and the planned line would not have such a huge accessibility improvement.

- Future directions
  - Possibly adding attractiveness of the locations where stops/ stations are sitting
  - Integration of the concept of equity

Many thanks and…

This research was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2016S1A5A8017806).
We thank Professor Jongsoo Park for the help on the data analysis and our research assistant Soojeong Kim for collecting the spatial data.

Transit service level



Conceptual example of service level calculation

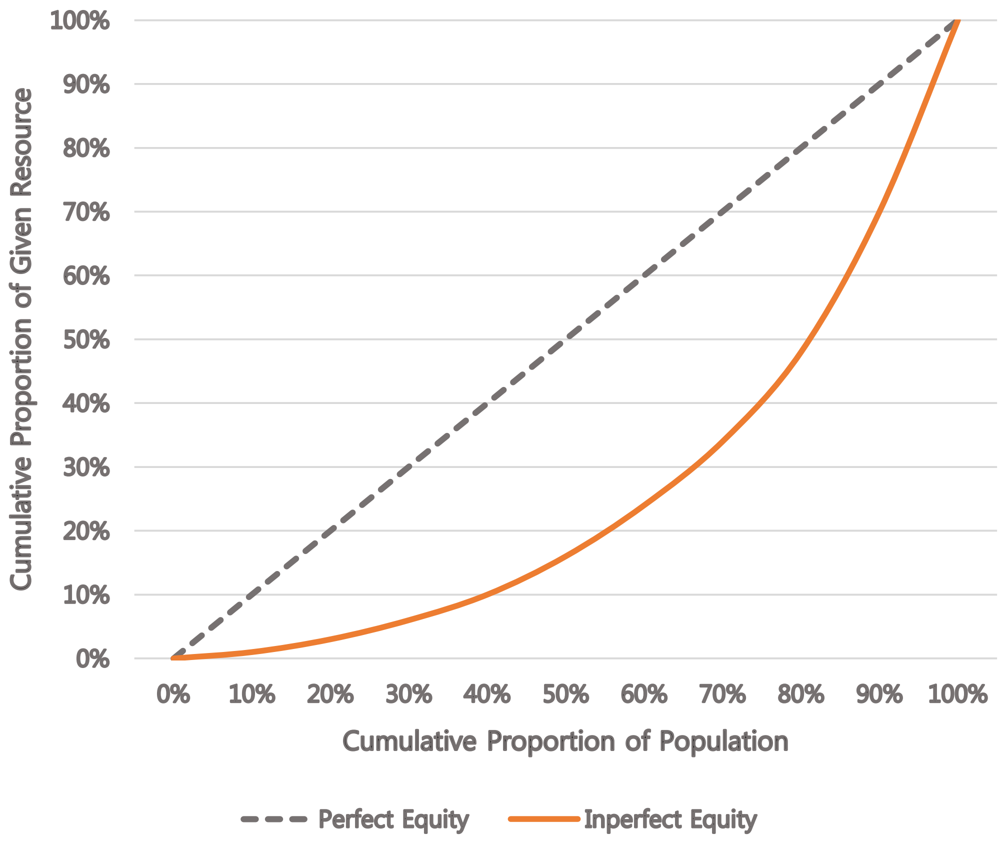
Transit service level

- The transit service provision was measured employing the Public Transit Index (PTI) suggested by Currie (2010)

$$PTI_i = \sum_{n=1}^{N} \left(\frac{Area_{Bn}}{Area_i} \times SL_{Bn}\right)$$

Where PTI_i is the public transit index of output area i, N is the number of access buffers in an OA, B_n is the buffer n and SL the service level at B_n .

Global equity measure



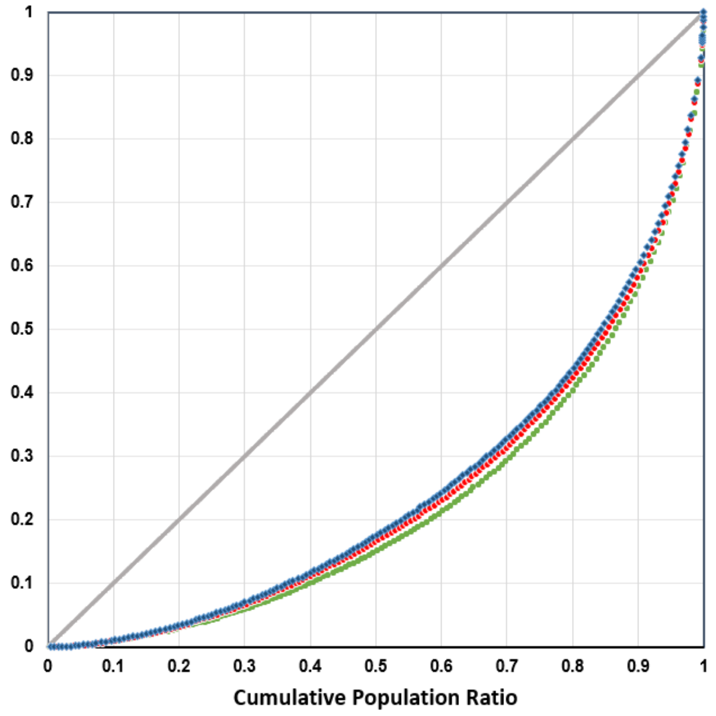
Example of the Lorenz Curve

The Gini index is approximately calculated using the equation suggested by Delbosc & Currie (2011), Welch & Mishra (2013) and Kaplan et al. (2014).

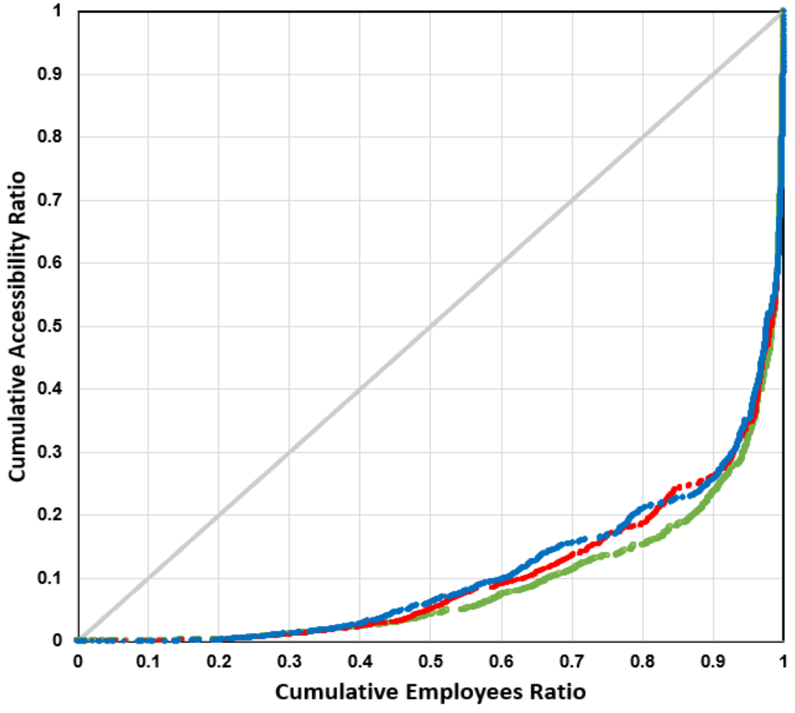
$$G = 1 - \sum_{k=1}^{K} (X_k - X_{k-1})(Y_k + Y_{k-1})$$

Where X_k is the cumulated proportion of the population variable (k=0, 1,…,K with X_0=0 and X_K=1), and Y_k is the cumulated proportion of the location-based accessibility measure (k=0, 1,…,K with Y_0=0 and Y_K=1).

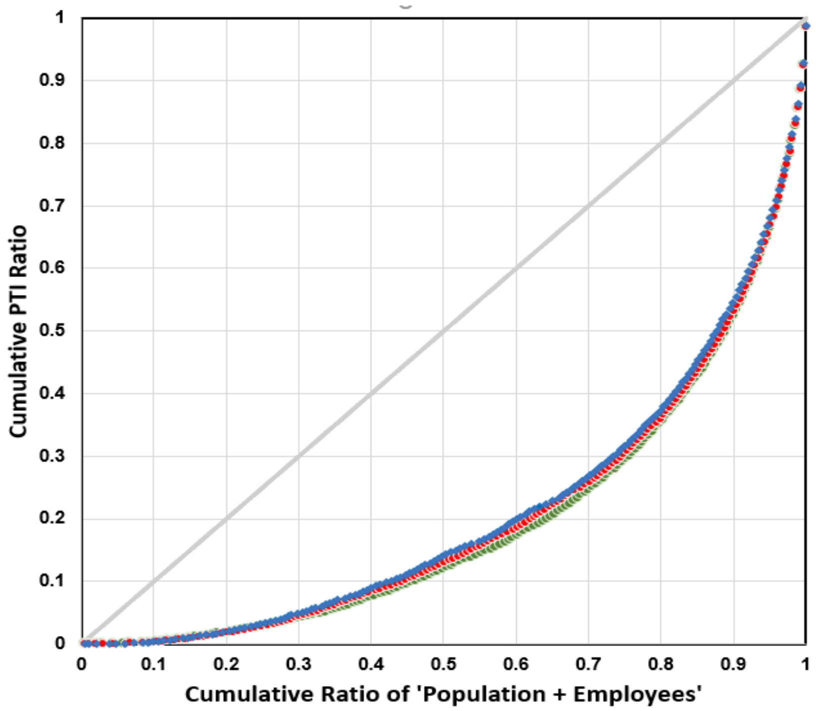
Results: Lorenz curves



(a) Residential population ratio only



(b) Employees ratio only

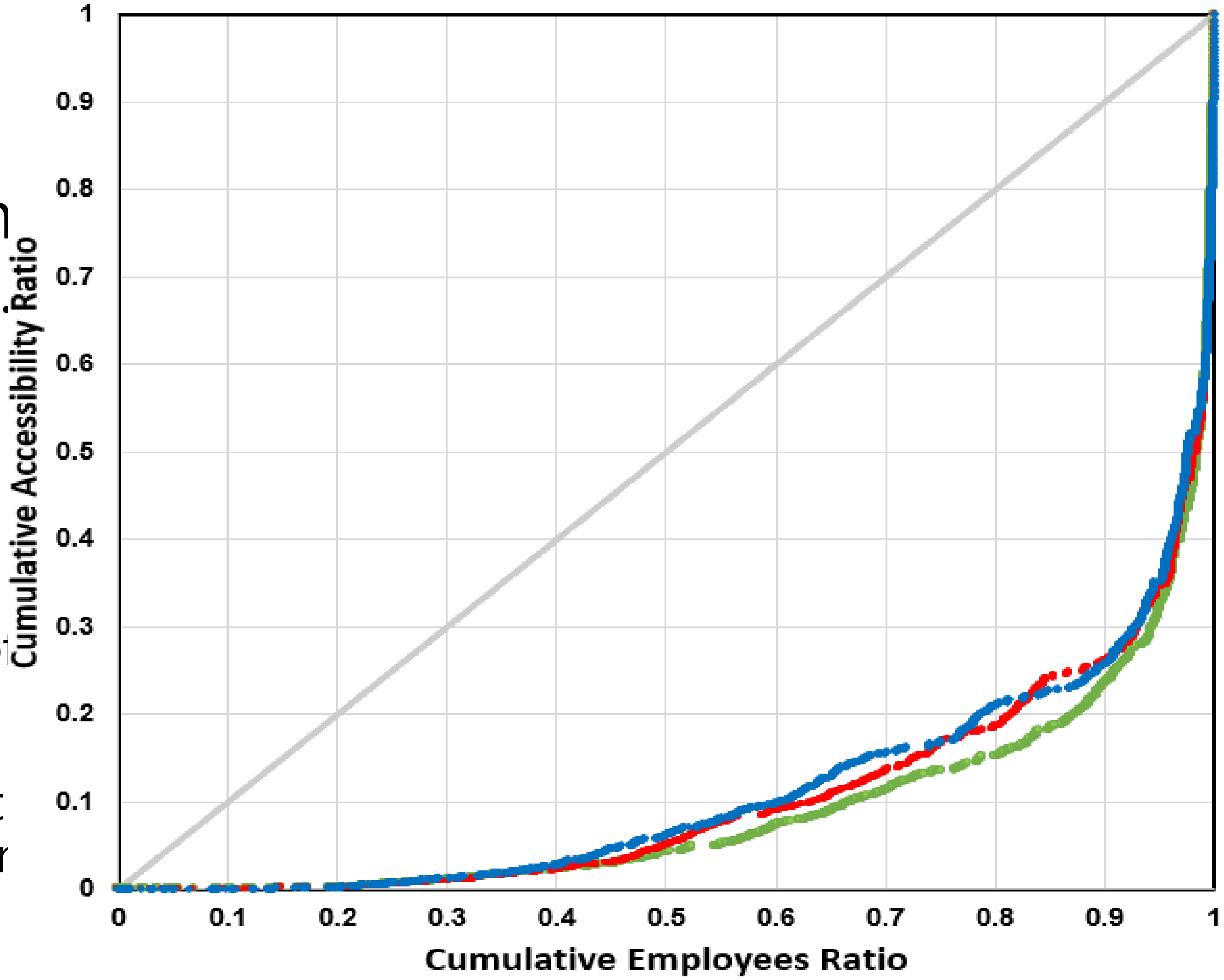


(c) Residential population and employees ratio

Results: Gini indices

Gini index	Stage 1	Stage 2	Stage 3	Sensitivity of transit equity		
Categories	Local bus only	Local bus + Subway line 1	Local bus+ Subway lines 1&2	Δ |stage1-stage2|	Δ |stage2 – stage3|	Δ |stage1 – stage3|
Residential population only	0.537	0.528	0.513	0.009	0.015	0.024
Employees only	0.823	0.795	0.781	0.028	0.014	0.042
Residential pop. plus Employees	0.609	0.596	0.581	0.013	0.015	0.028

Discussion: Lorenz curves & Gini indices



- Both the … the evolution … it equity in Gwangju…
- Different … rovement patterns

- Oscillation o…
- Introduction … ity
- Employment … opulation level was to subway li…