Valuing Convenience in Public Transport in the Korean Context

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I. Valuing Convenience: A Case Study of Seoul

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1. Needs for Scientific Transport Policy Intervention

- Huge social costs due to transport:

  - Congestion cost alone exceeds 27 trillion won annually (about 240 billion US dollars) in Korea

- We usually know about policy impact directions but not about effectiveness

  - This requires quantitative policy impacts analysis
  - Econometric analysis on demand elasticities

Social Costs in Transport Sector

Unsafe Traffic	Highest level of traffic accident death rate out of OECD (32 nations) - 2.64 death per 10,000 cars in '11 (OECD average death: 1.06 people)
Congested Road	Additional social expenses due to annual increase in congestion fee - Congestion Cost : 25.9 Trillion Won('07) → 26.9 Trillion Won('08) → 27.7 Trillion Won ('09)
Road Traffic that Accelerates Global Warming	Road traffic takes up 94.4% of greenhouse gas emissions in transportation - Transportation Greenhouse Gas Emission in '09년 : 82.56 million tons CO_2eq (Road Traffic: 77.94 million tons)
Increase of Physically Disadvantaged People	Increase in physically disadvantaged due to entering the aging society - 12.418 million in '11 (24.5%) → Expected to increase to approximately 13.120 million in '16 (25.7%)
High Logistics Cost	Decrease in industry competitiveness due to additional logistics expense - National Logistics Cost in '09 : 115.499 Trillion Won (Annual average increase of about 1.26%)

2. Quantitative Policy Impact Analysis*

- Stated preference methodology for impact analysis of hypothetical transport policy measures

  - Bases for scientific transport policy intervention

- Econometric testing of transport policy related hypotheses

  - Perceived vs. real cost of transport

*Source: Sungwon Lee et al. (2008)

Valuing Convenience

- Concept and definitions of convenience in public transport
  - Amenities
  - Comfort level
  - Time related attributes: headway, in-vehicle time

- As people are more and more addicted to private modes of transport, people demand more comforts in public transports

- Importance of valuing convenience in public transports

Table 1. Elasticities of Demand for Urban Transportation

Demand	Attributes	Elasticities		
		Short run	Long run	Overall
Fuel consumption	Fuel price	-0.27	-0.73	-0.48
Car use	Fuel price	-0.33	-0.30	-0.39
Car ownership	Fuel price	*	*	-0.21
Car ownership	Car price	*	*	-0.87
Traffic	Toll fee	*	*	-0.45
Demand for bus	Bus fare	-0.30	-0.65	-0.41
Demand for subway	Subway fare	-0.20	-0.40	-0.20
Demand for rail	Railway fare	-0.70	-1.10	-0.65
Mass transit	Fuel price	*	*	+0.34
Car ownership	Transit fare	*	*	+0.10

Note: Short run means usually within a year, and long run means 5 to 10 years.
Source: UK Department of Transport

SP Methodology and Estimation Results

- If variables are too numerous and too widely varied
  → impossible to create all the possible sets of SP questionnaires
- Use fractional factorial plan which analyzes only main effects and guarantee the orthogonality of variables following Kocur et al.(1982) and Hensher(1994)
- SP design of mode choice between passenger cars and alternative modes of bus and subway
- Explanatory variables
  → travel expense, travel time, and service levels

Table 2. SP Design of Mode Choice between the Alternative Modes

Modes	Explanatory variables	# of Levels	Levels		
			Level 1	Level 2	Level 3
Basic mode (private automobile)	Fuel price (per litter)	3	Current level (1,200 won)	Increase to 1,500 won	Increase to 1,800 won
	In-vehicle time	3	Current level	20% higher	40% higher
	Monthly parking fee	3	Current level (150,000 won)	40,000 won higher	80,000 won higher
Alternative mode (bus and subway)	fare	3	400 won lower	200 won lower	Current level (500~1,000won)
	In-vehicle time	3	40% lower	20% lower	Current level
	Out-vehicle time	3	50% lower	25% lower	Current level
	Congestion (comfortable)	3	No congestion	Medium congestion	High congestion

Note: US $ 1.00 is equivalent to 1,120 Korean Won as of Aug 15, 2013

■ Utility functions

$$U_{oricar} = \alpha + \beta_1 \cdot Fuel + \beta_3 \cdot Ivt + \beta_5 \cdot Park$$

$$U_{altmode} = \beta_2 \cdot Fare + \beta_3 \cdot Ivt + \beta_4 \cdot Ovt + \beta_6 \cdot Crowd$$

where *altmode = bus, subway, bus + subway*

- Surveyed on 662 car users → binary choice with multiple levels of attributes → 4,228 effective data sets
- Main purpose of using passenger cars

✓ Commuting (71.5%)

✓ Business trips (16.4%)

- Although most variables were statistically significant, fare of mass transit was statistically insignificant
  → car users do not consider fare level as significant since fare is significantly smaller than user expense of a car
- Positive car dummy → prefer car to mass transit
- Demand elasticity of fuel price is much higher than that of fare level, as fuel expense is far more significant than fare
- Car users respond to bus fare changes more than subway fare changes

- Bigger coefficient of out-vehicle time than that of in-vehicle time → bigger disutility of waiting than riding
- Bus users are more sensitive to in-vehicle time than other modes → recommend express bus or HOV lanes
- Estimated coefficient of parking fees is more than two times bigger than that of fuel prices → perceived cost of parking is much greater than fueling and car users are very sensitive to parking fees
- Positive and bigger coefficient of Crowdedness of bus than that of subway → very sensitive to crowded bus

Table 3. Estimation Results of Mode Choice Behavior of Car Users

Variables	car → bus		car → bus + subway		car → subway	
	coefficient	t-value	coefficient	t-value	coefficient	t-value
Car dummy	1.6362	5.505	0.99752	5.207	0.50605	2.29
Fuel price	-1.01E-04	-3.067	-1.17E-04	-5.241	-6.10E-05	-2.848
Fare of bus or subway	-2.00E-04	-1.456	-1.41E-04	-2.862	-5.40E-05	-0.637
In-vehicle time	-4.21E-02	-8.106	-2.76E-02	-9.376	-3.80E-02	-10.717
Out-vehicle time	-4.41E-02	-3.486	-2.81E-02	-5.053	-6.49E-02	-7.089
Parking fee	-3.63E-04	-6.36	-2.49E-04	-6.188	-2.61E-04	-6.018
Crowdedness	0.83081	8.38	0.64431	9.306	0.58023	7.508
ρ^2 (Rho square)	0.19		0.20		0.22	
No. of responses	943		1,783		1,502	

3. Policy Implications

- Estimate price elasticities through Sample Enumeration method
  → obtain arc elasticity rather than point elasticity
- Fuel price elasticity of demand for passenger car use
  → -0.078~-0.171(inelastic)
- With 50% increase in fuel price, modal change from car to bus or subway is expected at minimum 3.9% to maximum 8.5%
- Dual users of bus and subway show higher price elasticity than single users → more sensitive to fuel price as they are relatively longer-distance commuters

Table 4. Fuel Price Elasticities of Demand for Car Use and Change of Modal Share

		Fuel Price Elasticities	Modal change from car to transit modes (%)
Car-bus	10% price increase	-0.086	0.86
	20% ”	-0.086	1.72
	30% ”	-0.086	2.59
	40% ”	-0.086	3.45
	50% ”	-0.086	4.32
Car-subway	10% ”	-0.078	0.78
	20% ”	-0.078	1.55
	30% ”	-0.078	2.33
	40% ”	-0.078	3.11
	50% ”	-0.078	3.88
Car-bus+subway	10% ”	-0.171	1.71
	20% ”	-0.171	3.41
	30% ”	-0.171	5.11
	40% ”	-0.171	6.79
	50% ”	-0.169	8.47

II. Rationale behind Policy Reform

- Estimate cross price elasticity of demand for passenger car use through sample enumeration technique

  → 0.016~0.087 (inelastic) in Table 8
- Modal change from car to mass transit with 50% fare decrease → 4.35% at most

  → policy of subsidizing transit fare is not expected to reduce car use

Table 5. Fare Elasticities of Demand for Car Use and Change of Modal Share

		Fare (cross price) elasticity	Modal change from car to transit modes (%)
Car-bus	10% fare decrease	0.058	0.58
	20% ”	0.058	1.16
	30% ”	0.058	1.75
	40% ”	0.058	2.33
	50% ”	0.058	2.92
Car-subway	10% ”	0.016	0.16
	20% ”	0.016	0.33
	30% ”	0.016	0.49
	40% ”	0.016	0.66
	50% ”	0.016	0.82
Car-bus+subway	10% ”	0.086	0.86
	20% ”	0.086	1.73
	30% ”	0.087	2.60
	40% ”	0.087	3.47
	50% ”	0.087	4.35

- Test whether "car users consciously perceive parking costs more than fuel costs (Button, 1993)
  → whether the estimates of the coefficients of fuel price and parking fees are the same
  → Asymptotic t-test
  → Reject at 5% significance level

$$\frac{\hat{\beta}_i - \hat{\beta}_j}{\sqrt{\operatorname{var}\left(\hat{\beta}_i - \hat{\beta}_j\right)}}$$

Table 6. Results of Asymptotic t Test for Indifference between Variables

Modes	Asymptotic t Test Statistic	Results
Car-bus	4.08	Reject null
Car-subway	4.22	Reject null
Car-bus+subway	2.95	Reject null

II. Rationale behind Policy Reform

- Increase of monthly parking fee by US $33.00
  → decrease car use by 13~15%
- Increase of monthly parking fee by US $66.00
  → decrease car use by 25~30%
- Each current individual level of parking fee is not the same → cross price elasticity of parking fee cannot be estimated

Table 7. Change of Modal Share due to Increasing Parking Fee

			Modal change due to the change of parking fee	Modal Change (%)
+40,000 won per Month	Car-bus	Car	0.660 → 0.562	-15
		Bus	0.340 → 0.438	29
	Car-subway	Car	0.576 → 0.502	-13
		Subway	0.424 → 0.498	18
	Car-bus+subway	Car	0.567 → 0.495	-13
		Bus+subway	0.433 → 0.505	17
+80,000 won per month	Car-bus	Car	0.660 → 0.460	-30
		Bus	0.340 → 0.540	59
	Car-subway	Car	0.576 → 0.428	-26
		Subway	0.424 → 0.572	35
	Car-bus+subway	Car	0.567 → 0.423	-25
		Bus+subway	0.433 → 0.577	33

Time Elasticities, Response to Service Variable, and Policy Effects

- Estimate cross elasticity of in-vehicle time of transit for demand for car use using sample enumeration technique
- Decrease in-vehicle time of transit by 10~50%
  → cross elasticity 0.46 ~0.57
- Speed of subway improves two folds
  → 29% of car users transfer to subway
- **Introducing either express subway transit system or express bus will be an effective policy in reducing car use and traffic congestion in Seoul**

Table 8. In-vehicle Time Elasticities of Demand for Car Use and Modal Share

		In-vehicle (cross) time elasticity	Modal change from car to transit modes (%)
Car-bus	10% decrease	0.459	4.59
	20% ”	0.471	9.42
	30% ”	0.481	14.43
	40% ”	0.489	19.57
	50% ”	0.495	24.77
Car-subway	10% ”	0.549	5.49
	20% ”	0.559	11.18
	30% ”	0.567	17.01
	40% ”	0.572	22.89
	50% ”	0.575	28.73
Car – bus + subway	10% ”	0.512	5.12
	20% ”	0.517	10.35
	30% ”	0.520	15.61
	40% ”	0.521	20.84
	50% ”	0.520	25.99

- Estimate cross elasticity of out-vehicle time of transit for demand of car use with sample enumeration technique → smaller than that of in-vehicle time
- Decrease out-vehicle time of transit by 10~50%
  → cross elasticity 0.19 ~0.38
  → modal change up to 19%
- Policy of increasing frequency of bus and subway
  → very effective for promoting use of transit modes and reducing traffic congestion in Korea

Table 9. Out-vehicle Time Elasticities of Demand for Car Use and Modal Share

		Out-vehicle (cross) time elasticity	Modal change from car to transit modes (%)
Car-bus	10% decrease	0.197	1.97
	20% ”	0.200	3.99
	30% ”	0.202	6.05
	40% ”	0.204	8.15
	50% ”	0.206	10.28
Car-subway	10% ”	0.364	3.64
	20% ”	0.369	7.38
	30% ”	0.373	11.20
	40% ”	0.377	15.08
	50% ”	0.380	18.99
Car – bus + subway	10% ”	0.208	2.08
	20% ”	0.210	4.19
	30% ”	0.211	6.33
	40% ”	0.212	8.48
	50% ”	0.213	10.65

II. Rationale behind Policy Reform

- Level of service in transit modes is defined as the level of crowdedness in this study
- Decrease congestion of transit modes by one step

  → 18~25% of car users transfer to alternative modes

  → improving in-vehicle congestion is very important for promoting the use of transit modes and reducing traffic congestion in Seoul

Table 10. Car Users' Response to Service Variable of In-vehicle Congestion

		Change of modal share
Car-bus	Improving one step	25.05 % from car to bus
	Worsening one step	21.92 % from bus to car
Car-subway	Improving one step	17.85 % from car to subway
	Worsening one step	17.47 % from subway to car
Car – bus + subway	Improving one step	20.71 % from car to bus + subway
	Worsening one step	20.46 % from bus + subway to car

Public Transit User Subsidy and the Policy Effectiveness

- If 100% public transit user subsidy is implemented, 18% of current private vehicle user will switch over to public transport
- If this policy is supplemented by commuter parking fee increase ($ 100/month), the modal share change is estimated at 28%.

Table 11. Car Users' Response to Public Transit User Subsidy

Policy Scenarios	Commuting Mode	Modal Share	Conversion Rate to Public Transport	90% Confidence Interval
Baseline	Private Car	39.6	N.A	N.A
	Public Transport	60.4		
25% Public Transport Subsidy	Private Car	36.8	4.7	3.1~6.2
	Public Transport	63.2		
50% Public Transport Subsidy	Private Car	34.0	9.3	8.0~10.4
	Public Transport	66.0		
75% Public Transport Subsidy	Private Car	31.4	13.6	12.4~14.8
	Public Transport	68.6		
100% Public Transport Subsidy	Private Car	29.0	17.7	16.1~19.2
	Public Transport	71.0		

Summary of Policy Implications

- Could analyze the effects of hypothetical TDM policies in terms of modal changes utilizing elasticity estimates
- Ineffective policy measures
  - ✓ Small effect of fuel price policy
  - ✓ Fare related policy (Excluding user subsidy)
- Effective policy measures
  - ✓ Parking regulation or pricing policy
  - ✓ Express bus, express urban trains, and HOV lanes
  - ✓ Reducing crowdedness in bus and subway through increasing frequency
  - ✓ Public transit user subsidy

II. Seoul's Transport*

1. General Information
2. Changes in Seoul: Urban Sprawl
3. Changes in Seoul: Motorization
4. Changes in Seoul: Infrastructure
2. Changes in Seoul: Transport Conditions

*Source: Jin Young Park, *Public Bus Service Modernization* (2013)

1. General Information

SMA: Seoul, Incheon and Gyeonggi

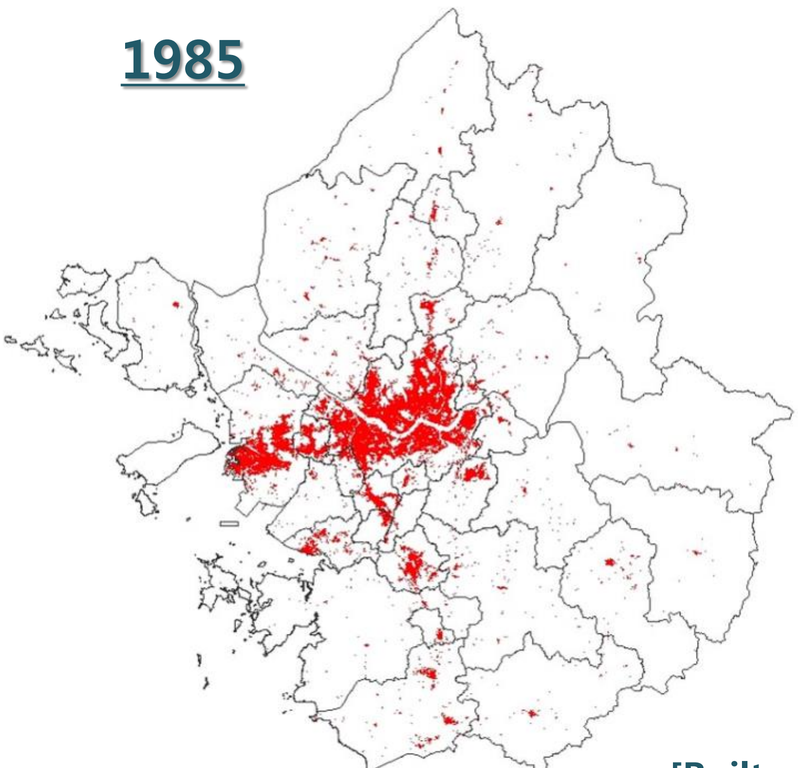
	Seoul	SMA
Area	605.2 km^2 (0.6%)	11,818 km^2 (11.8%)
Population	10.0 million (20.1%)	26.6 million (49.3%)
GRDP	283,651 billion won (22.8%)	585,978 billion won (47.1%)

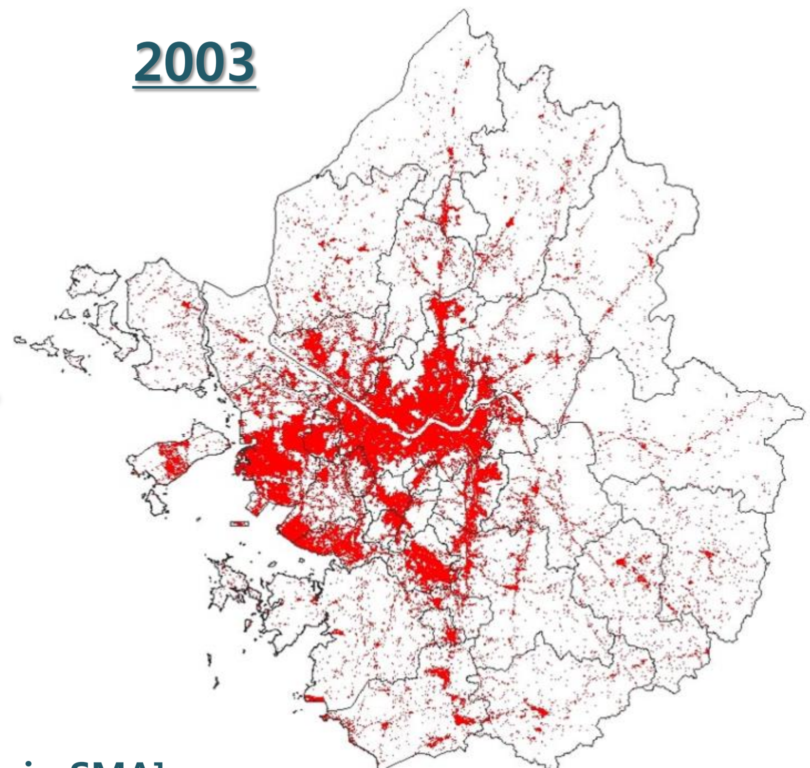
* Source: e-National Indicators (2011)

[Seoul Metropolitan Area in Korea]

2. Changes in Seoul : Urban Sprawl

	Towns	Area	Population	House
1st (1989~1996)	5	50.1km^2	1.17 million	292 thousand
2nd (2001~2012)	12	146.1km^2	1.75 million	671 thousand

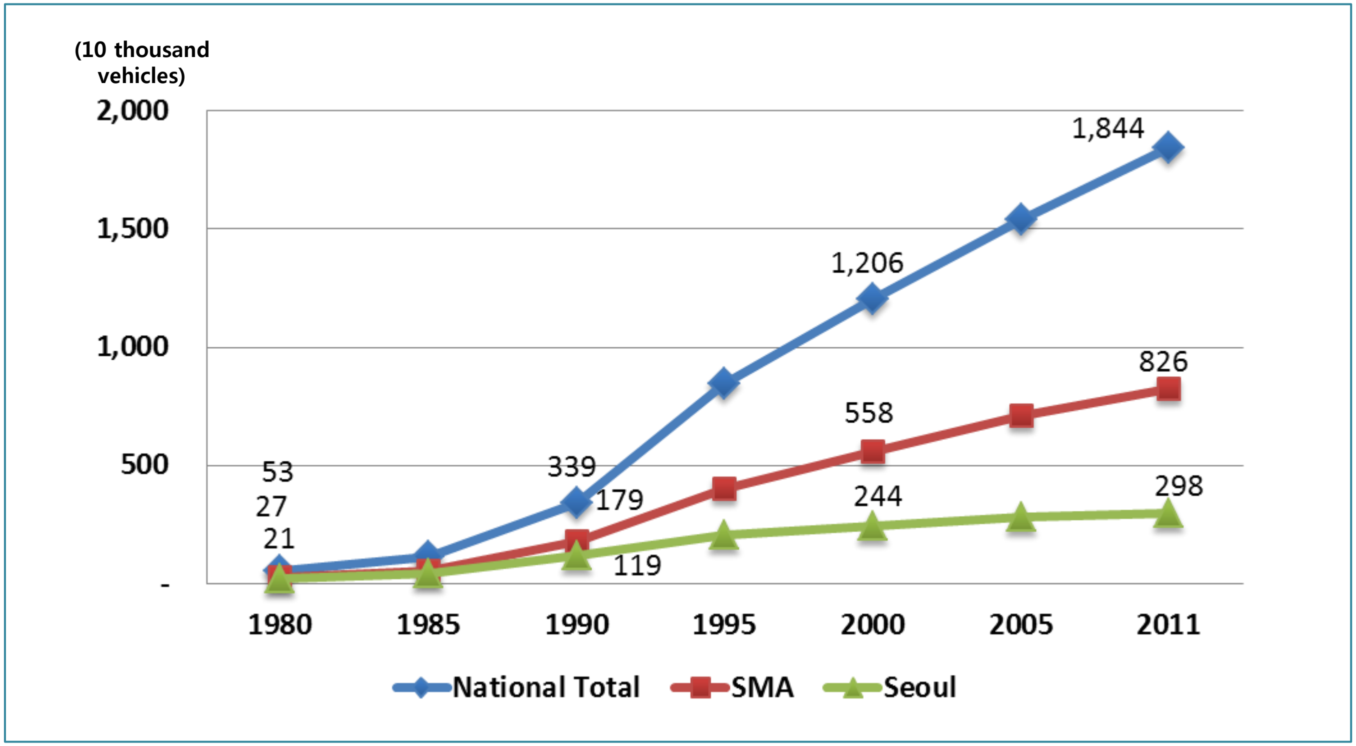




[Built up Areas in SMA]

3. Changes in Seoul : Motorization

- **Seoul: 0.02 (1980) → 0.11 (1990) → 0.24 (2000) → 0.3 (2011) veh/person**



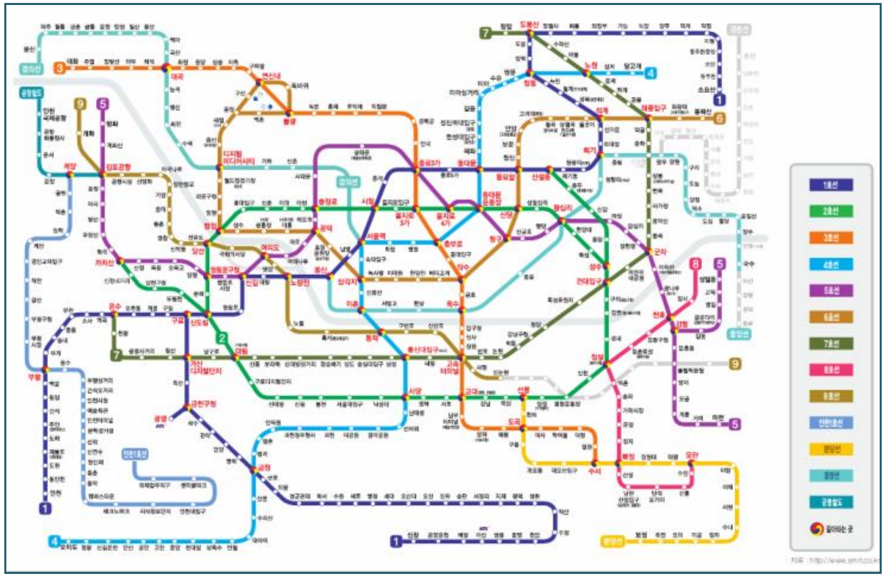
[Trends of Vehicle Registration]

* Source: e-National Indicators (2011)

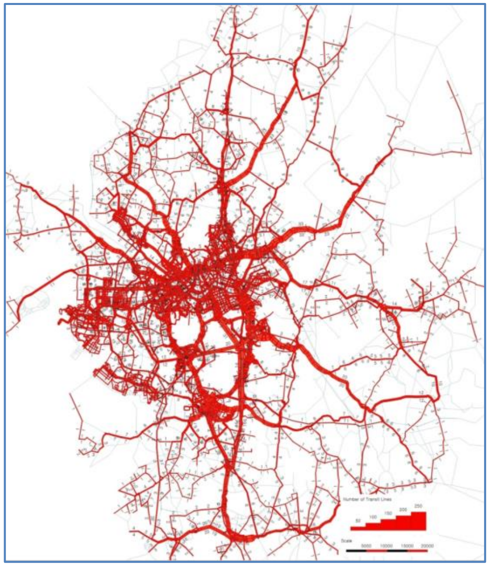
4. Changes in Seoul : Infrastructure

Transport Infrastructure

	Seoul	SMA
Road	8,199 km	24,070 km
Bus	447 Lines (9,340 Vehicles)	3,694 Lines (26,847 Vehicles)
Railway	346.3 km (321 Stations)	825.2 km (521 Stations)



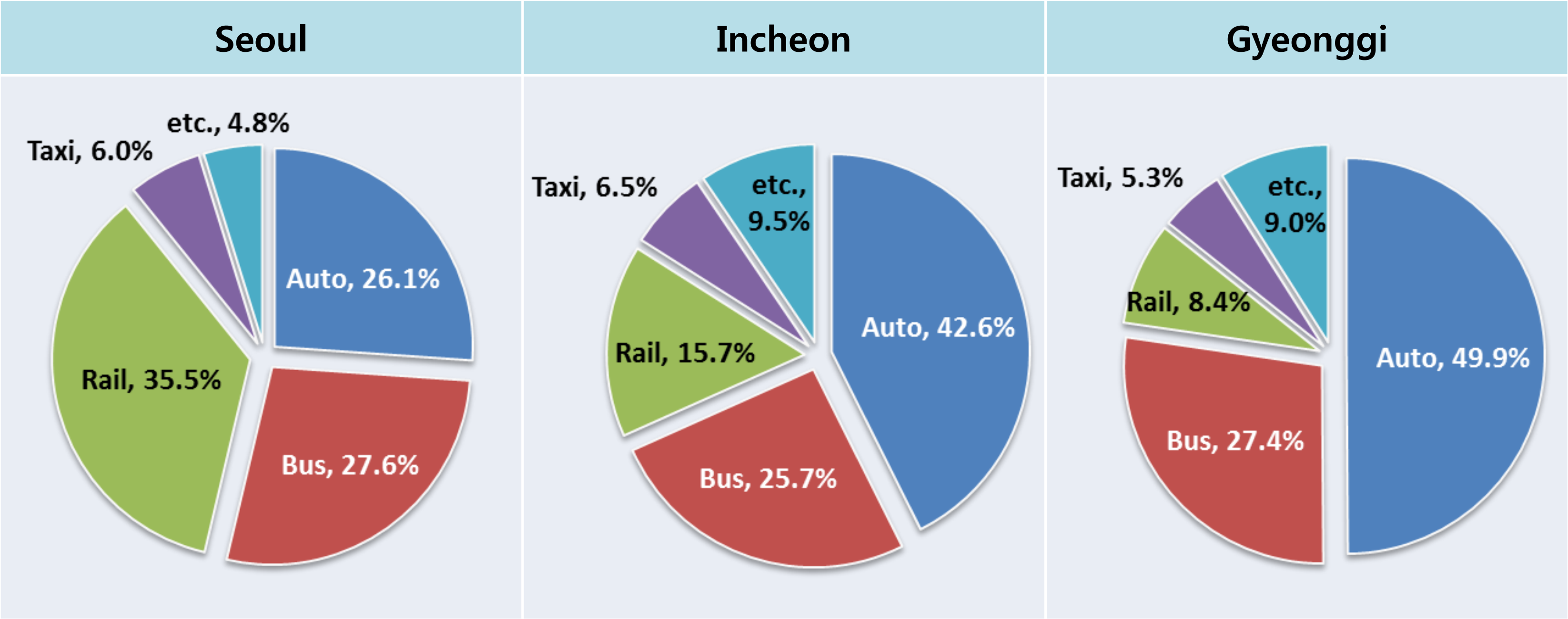
[Railway Networks and Stations in SMA]



[Bus Network and Capacity in SMA]

5. Changes in Seoul : Transport Conditions

Daily Trips and Mode Share



- Seoul intra-city trips: 20,011 thousand trips per day
- SMA intra-city trtips: 49,660 thousand trips per day

* Source: Metropolitan Transportation Authority

III. Inferences from the Public Transport Reforms

1. Public Transport Reform in Seoul

2. Bus System Modernization

3. Outcome of the Reform

1. Public Transport Reforms

Vicious Circle of Bus Service

Increasing vehicles

Ineffcient bus management system

Limited road capacity →congestion

- Lack of bus priority policies (bus lane & subsidies)

- Worsen bus operating conditions

- abolition of route, → reduced operation,
- periodic increase of fare
- labor dispute → inconvenience for citizen

- Poor punctuality
- Poor reliability
- Slow speed

- stress on driver from traffic congestion
- unfriendly to passenger, and causing accident

- no other options except periodic fare raising

- Decrease of bus users
- Abolition of bus service
- Bankrupt of bus company

Vicious Circle of Bus Service

- Unstable Service by deteriorated bus company
  - → Unpunctuality, abolition of bus routes
- Unstable employment
  - → Continuous reduction of labor (driver's low salary)
- Excessive competition to increase revenue
  - → Reckless driving : accident, uncomfortable ride
- Routes owned by private bus company
  - → Hard to adjust routes by demands

Bus System Modernization

- **Operation Scheme :** New revenue system
- **Network :** Trunk & Feeder
- **Fare :** Distance-based free transfer fare with smart card
- **Information :** Bus Management/Information System
- **Infrastructure :** Exclusive bus lane, Station improvement
- **Fleet :** CNG bus, Low-floor bus

2. Bus System Modernization

Operation Scheme

- Introduction of bidding main routes
- Joint management of revenue
- Reform of revenue structure based on operating distance

Previous system	New system
Revenue based on number of Passengers	Revenue based on Service distance (Veh-km)

2. Bus System Modernization

Network : Trunk Lines · Feeder Lines · Circular · Wide Area

- Regional connection between suburbs and downtown area
- Ensuring operation speed and punctuality

→ **Trunk lines** → **Blue bus**

- feeder to trunk lines and subways
- Meeting local traffic demand

→ **Feeder lines** → **Green bus**

- Local lines within the downtown area
- Serving for business and shopping trips

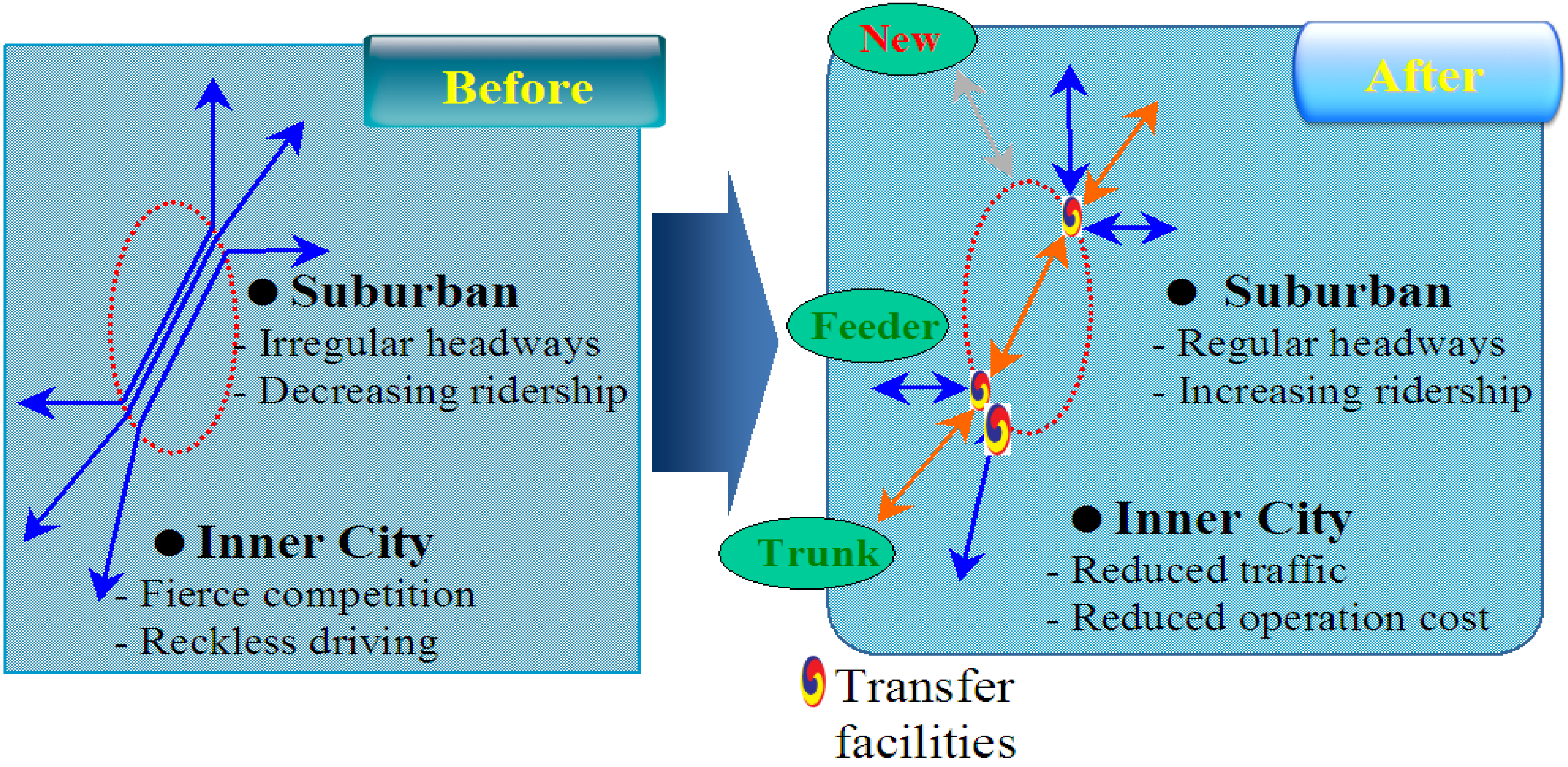
→ **Circular lines** → **Yellow bus**

- Express connection between satellite cities and downtown area
- Absorbing passenger car commuters

→ **Wide area lines** → **Red bus**

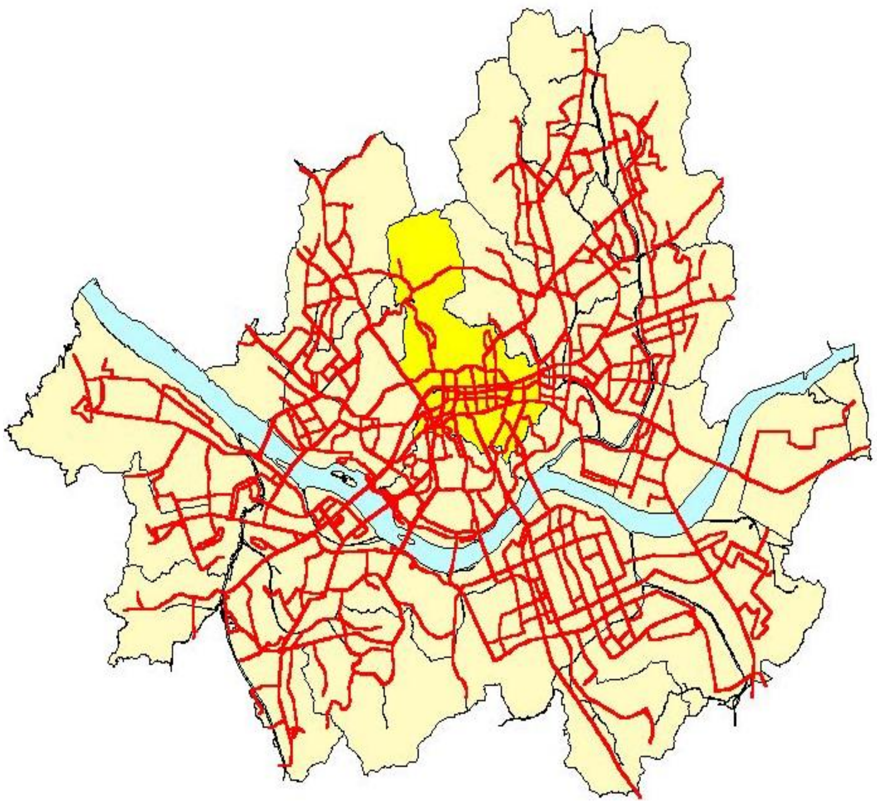
2. Bus System Modernization

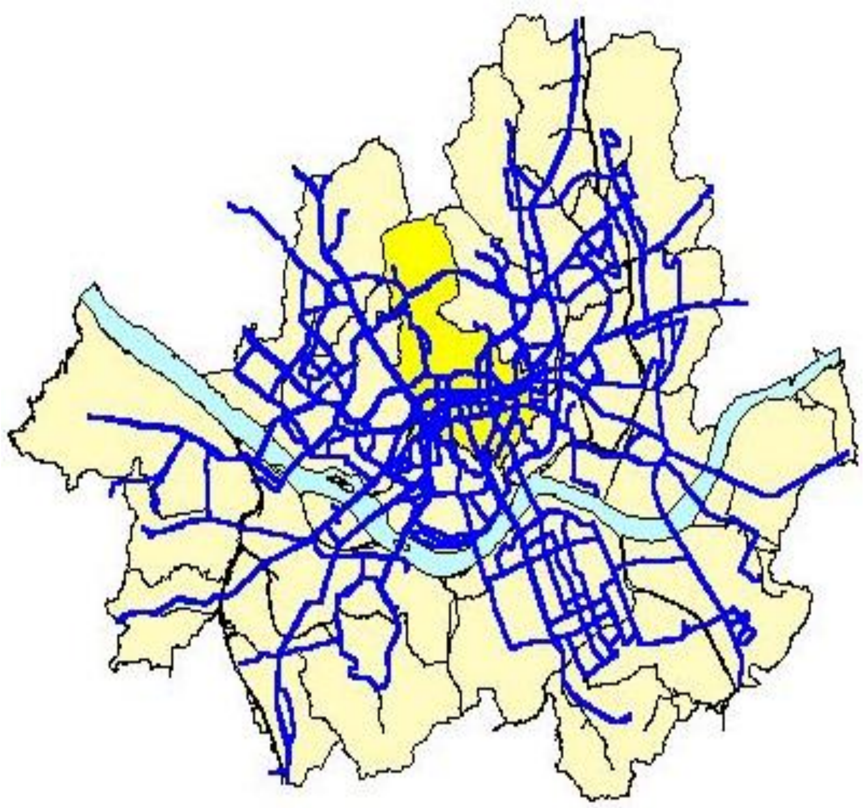
Network : Trunk & Feeder



2. Bus System Modernization

- **Network : Trunk & Feeder**





2. Bus System Modernization

Distance based fare

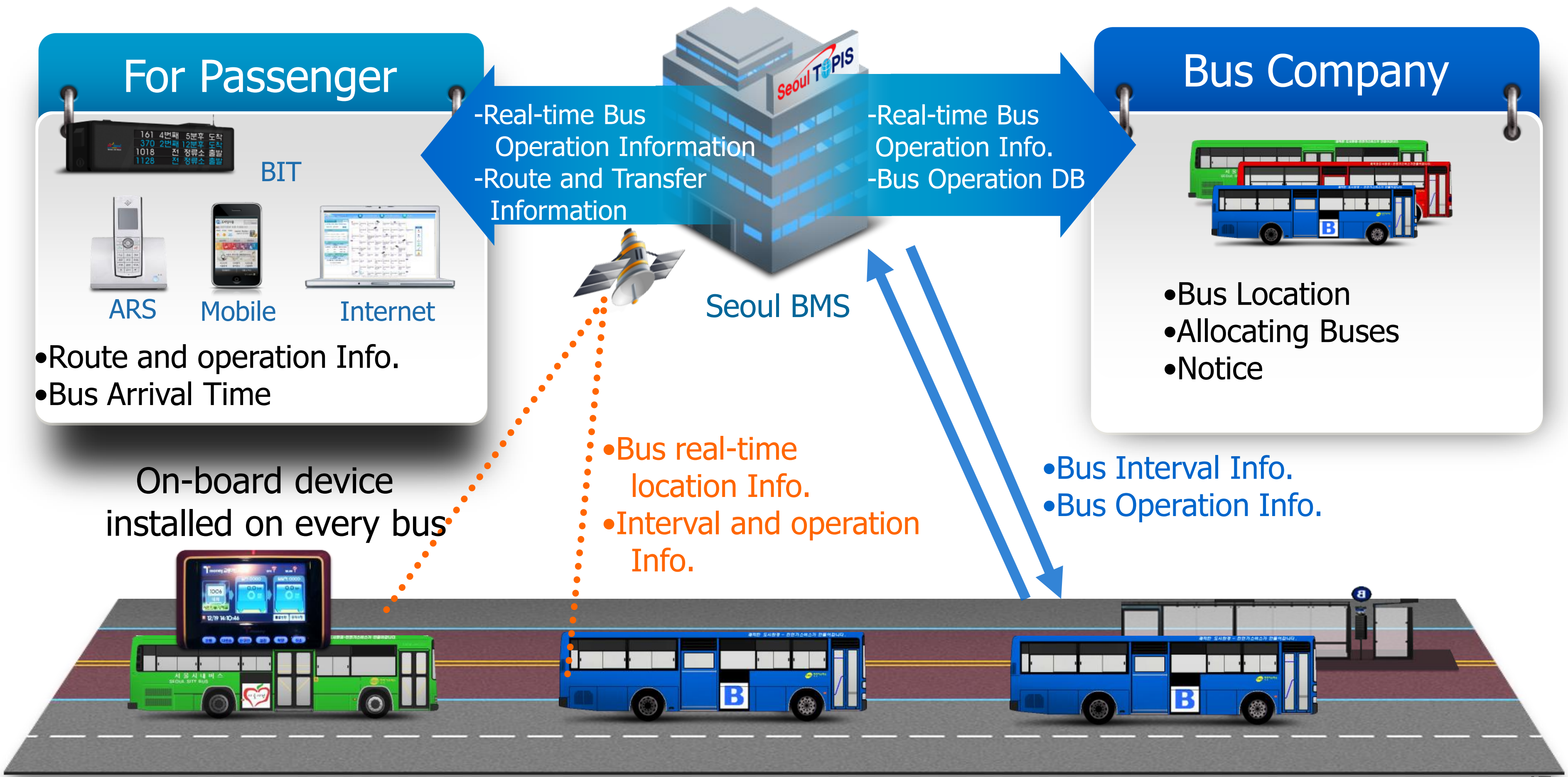
- Subway single trips
  : fare according to distance-traveled
  (basic fare : 1,000 Korean won (1 US Dollar) up to 12 km;
  extra fare of 100 Korean won for every additional 6 km)
- Bus single trips : single fare of 1,000 won

Free of charge for transfers

- For transferring trips
  : accumulated distance-based fare system
  →(basic fare up to 10km;
  extra fare for every additional 5 km)

2. Bus System Modernization

- Bus Management System : Efficient management of bus services



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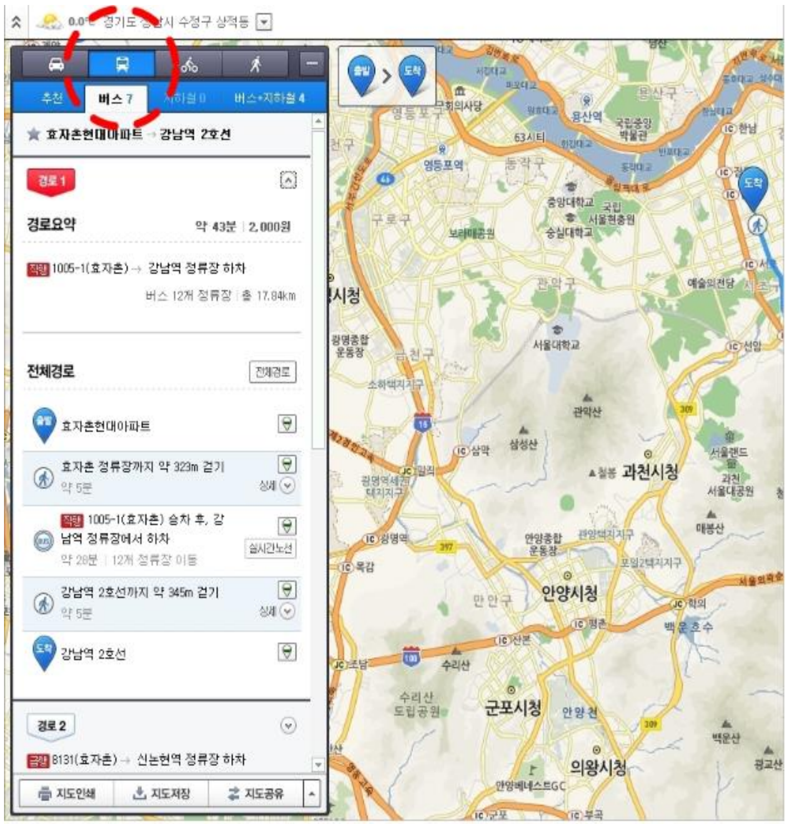
2. Bus System Modernization

- **Bus Information System**

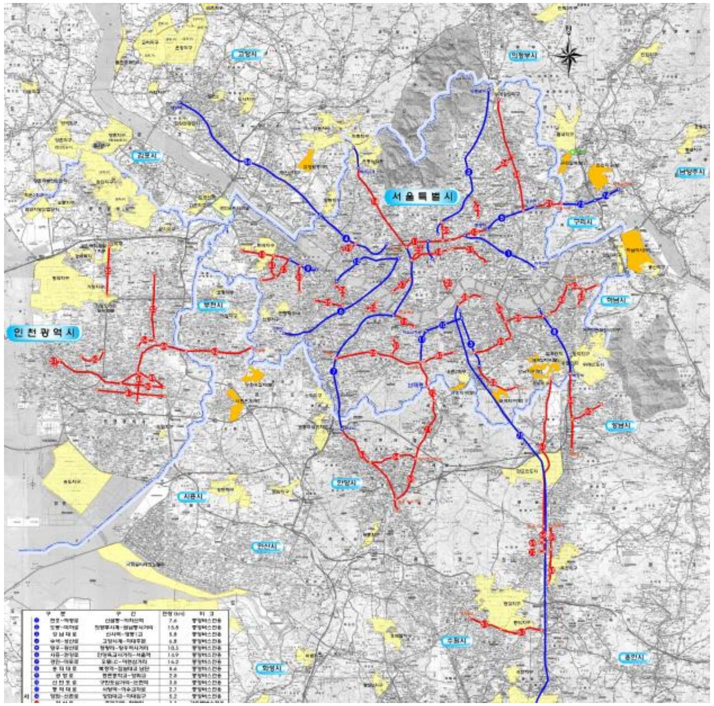


2. Bus System Modernization

Exclusive Bus lane

- Provides faster and reliable travel within the service area
- Seoul Metropolitan Area: 13 corridors, 157km (2011)
- Attracts patronage from private vehicles

Median exclusive bus lane



Bus lane Network In Seoul

2. Bus System Modernization

Bus Station Improvement

Stops Improvement

Before

Shelter & Fence installation

After

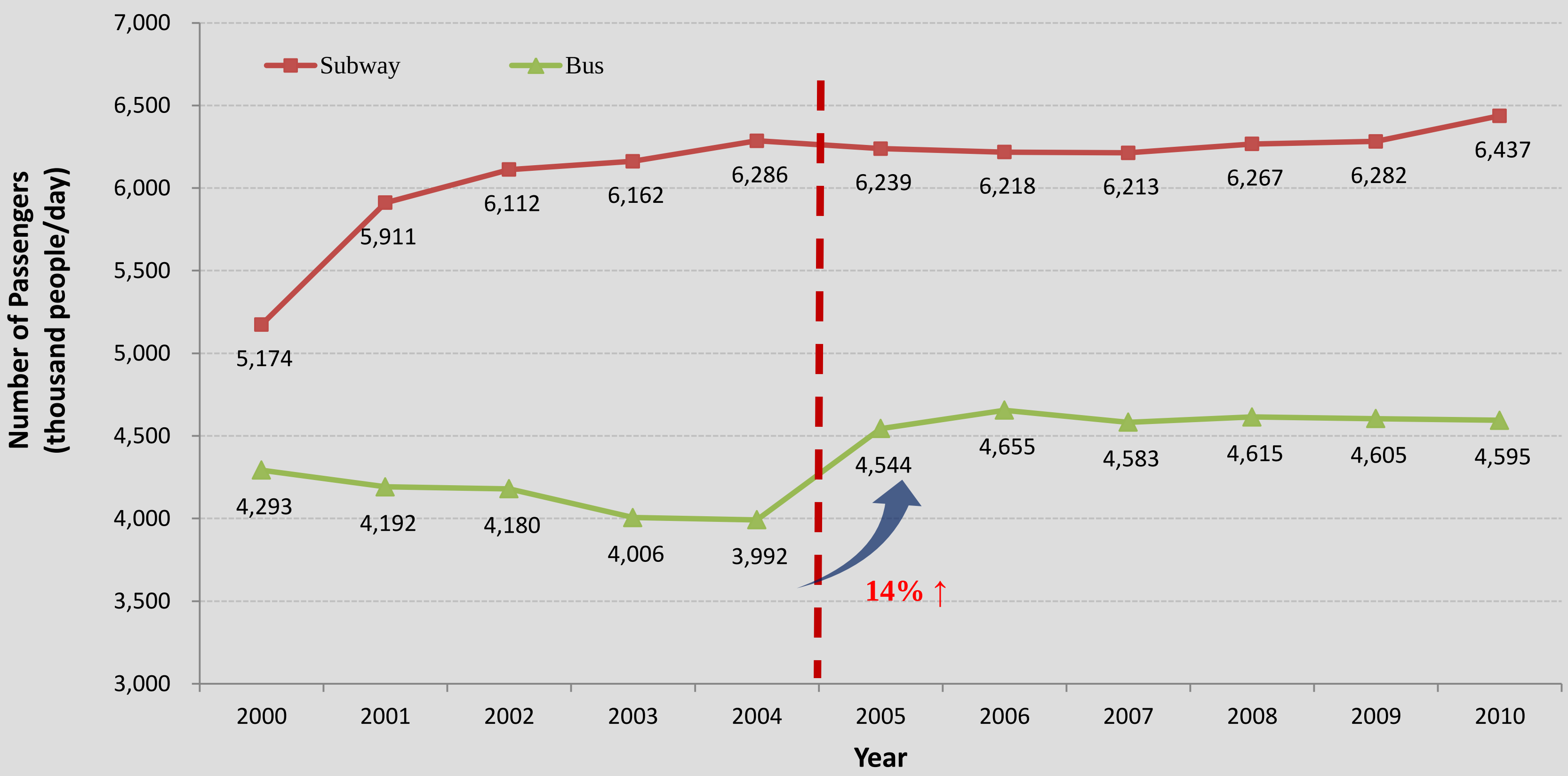
2. Bus System Modernization

Fleets

Trunk lines	Major lines	Articulated buses, Low-floor buses, CNG buses
	Aux. Trunk lines	Low-floor buses, CNG buses
Feeder lines		Medium-sized buses
Circular lines		Medium-sized buses

3. Outcome of the Reforms

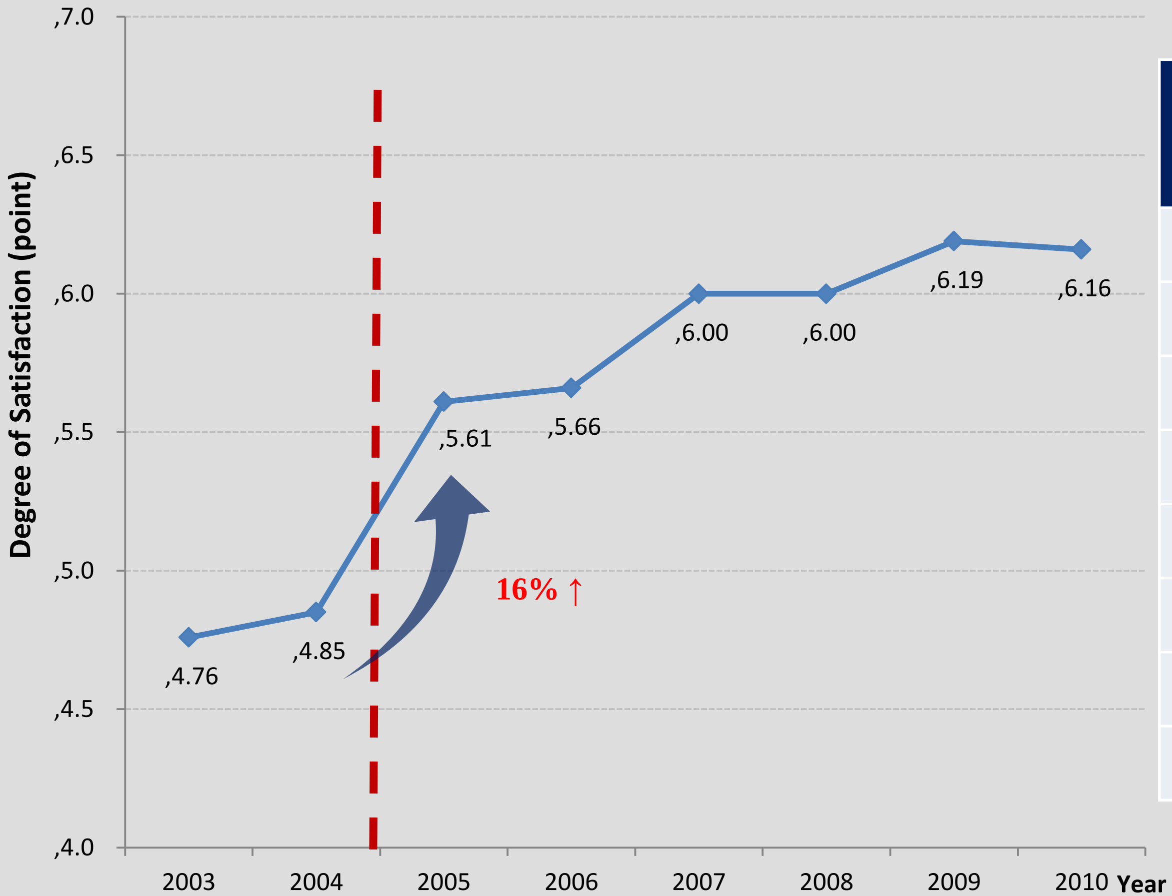
Increase in Public Transport Patronage



※ Subway ridership excludes free-pass holders.
Source : Seoul Year Book

Trend of Citizen's Satisfaction Degree for Transit Services

Satisfaction rate for Bus Service



Year	Public Transit	
	Bus	Subway
2003	4.76	5.99
2004	4.85	6.08
2005	**5.61**	**6.26**
2006	**5.66**	**6.30**
2007	**6.00**	**6.33**
2008	**6.00**	**6.30**
2009	**6.19**	**6.52**
2010	**6.16**	**6.71**

※ Rating is based on a scale of 0 to10.
Source : 2010 Seoul Survey

Valuing Convenience in the Korean Context

- Seoul's public transport reform is successful in attracting public transport's patronage
  - ➔ Increased competitiveness of public transport
- Increased convenience level of public transports
  - ➔ Reduced travel time
  - ➔ Free transfers
  - ➔ BIS system improvements
- Empirical evidences of the importance of convenience in public transport

Ⅳ. Discussions

Thank You.

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