International Transport Forum

Valuing Convenience in Public Transport in Korean Context

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Sungwon Lee, Ph.D.
The Korea Transport Institute

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Sungwon LEE
The Korea Transport Institute, Goyang-si, Korea

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ABSTRACT

Public transport patronage has been continuously declining in major Korean cities as levels of car ownership rise. Public transport has lost its competitive edge to private cars because people tend to prefer more convenient modes as their income increases. A promising way to reverse this trend is to provide more convenient modes of transport in terms of travel times and amenity. In Korea, we have implemented several policy measures aimed at increasing the attractiveness of public transport by reducing travel times and by providing more seats, etc. This paper analyses the post-policy impacts of these measures and compares the results with those of an ex ante quantitative policy effectiveness analysis. The main policy implication from the empirical analysis is that increasing the convenience level of public transport can be an effective way to increase public transport patronage. The measures to achieve this include reducing public transport travel times by increasing speeds or reducing headways, and by enhancing amenity levels. Following the reform of Seoul's public transport system, which reduced travel times by introducing exclusive median bus lanes and integrated public transport fares, we have actually seen an increase in the number of public transport users.

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1. INTRODUCTION

Public transport services such as urban rail and buses are regarded as energy-efficient and environmentally friendly forms of transportation in many cities around the world. However, public transport patronage has been continuously declining in major Korean cities in response to rising levels of car ownership. Public transport has lost its competitive edge to private cars because people tend to prefer more convenient modes as their income rises. A promising way to reverse this trend is to provide more convenient modes of transport in terms of time and amenity. In Korea we have implemented several policy measures aimed at increasing the attractiveness of public transport by reducing travel times and providing more seats, etc. This paper analyses the post-policy impacts of these measures which it then compares with the results of an ex ante quantitative policy effectiveness analysis. Policy implications will be drawn from the analysis.

Seoul, the capital city of Korea, conducted a major reform of its public transport system in 2004. The major components of this reform were the large-scale deployment of exclusive median bus lanes and the introduction of an integrated public transport fare system in which fares are charged according to the distance travelled, regardless of transport mode, by allowing free transfers between subways and buses. This fare system is designed to consist in a base fare which applies to the first 12 km of travel and an incremental fare reflecting the additional distance travelled. The result has been a resounding success. The reform has not only reversed the trend decline in public transport usage but has also increased the popularity of public transport modes in the capital city region of Korea.

This paper reviews the rationale behind the public transport reform by examining earlier quantitative impact studies of the effectiveness of policy instruments. The empirical study is based on stated preference methodology which analyses the impacts of hypothetical policy measures. The public transport reform is then discussed in detail and an ex ante evaluation made of the policy reform.

The results of this study could be transferable to other cities with similar characteristics. The policy recommendations could also be transferable in cases where such cities exhibit similar socio-economic and infrastructure-related conditions.

2. RATIONALE BEHIND PUBLIC TRANSPORT POLICY REFORM IN KOREA

In countries like Korea, characterised by a high population density and advanced urbanisation, public transport services such as subway and buses offer great potential for saving energy and for mitigating various social costs associated with private transportation. In order to promote public transport, policy measures aimed at increasing the attractiveness of public transport are required. Such policy measures include increasing both the convenience level of public transport, by reducing travel and waiting times, and the amenity level by providing greater comfort.

Although the policy impact targets are known, there are still uncertainties about the effectiveness of the policy. A quantitative policy impact analysis and econometric analysis of demand elasticities are therefore required.

The quantitative policy impact analysis discussed here uses the stated preference methodology for impact analysis of hypothetical transport policy measures. The outcome of this analysis is then used as the basis for evidence-based transport policy intervention. In addition, econometric analysis is performed to test the hypotheses of related transport policies in order to compare the perceived cost to the real cost of transportation. The table below summarises the findings of previous studies on the elasticities of demand for urban transportation.

Table 1. **Price 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 – full reference?

However, price and other elasticities of urban transport demand can vary from city to city, depending on the city's infrastructure conditions and the socio-economic conditions of its residents. A separate city-wise elasticity analysis is therefore required for evidence-based policy making.

Lee et al (2003) analysed the hypothetical policy measures' effectiveness in converting private car users to public transport in the Seoul metropolitan area by using discrete choice modelling based on stated preference methodology (SP).

A survey was conducted of 662 car users and produced 4,228 effective data points. The main purposes of passenger car use were for commuting (71.5%) and business trips (16.4%). The following formulas represent the utility function of cars and alternative modes (buses and subways):

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

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

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

(oricar: original mode of passenger car, altmode: alternative mode, bus: bus, sub: subway, bus+subway: dual use of bus and subway, Fuel: fuel price, Fare: fare of bus or subway, Ivt: in-vehicle time, Ovt: out-vehicle time, i.e., interval accessing bus and access time in the subway, Park: parking fee, Crowd: crowdedness, i.e., comfortableness as a service measure)

The table below represents the estimation results for the mode choice behaviour of car users. Although most variables were statistically significant, the fare for mass transit was statistically insignificant. This is because car users do not consider fare level to be significant as the fare is significantly lower than the cost of car use. Moreover, car users are more responsive to changes in bus fares than to changes in subway fares. The higher coefficient for out-vehicle time compared to that for in-vehicle time means that the disutility of waiting is greater than that of riding. Bus users are more sensitive to in-vehicle time than other modes and this suggests that an increase in express bus supply or HOV lanes can be effective in attracting bus users from cars. The estimated coefficient for parking fees is more than twice as high as that for fuel prices. This is because the perceived cost of parking is much greater than that of fuel, and car users are very sensitive to parking fees. The positive and higher coefficient for crowdedness in buses compared to the subway implies that car users are very sensitive to crowded buses.

Table 2. **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	

Price elasticities can be estimated through the sample enumeration method. This method obtains arc elasticity rather than point elasticity if the underlying utility function is properly specified. However, our model does not have components which allow varying elasticity due to estimation-related constraints. Theoretically, arc elasticity offers a more accurate response estimation when the hypothetical attribute level changes are large. As shown in the table below, the fuel price elasticity of demand for passenger car use ranges between -0.078~-0.171, which shows an inelastic behaviour. With a 50% increase in fuel price, a modal shift from car to bus or subway is expected at 3.9% minimum and 8.5% maximum. Additionally, dual users of bus and subway show a higher price elasticity than single users. This is because dual users are more sensitive to fuel price as they are relatively longer-distance commuters. Overall, the estimated transport demand elasticities in Korea are generally smaller than the U.K. elasticity cases shown in Table 1, reflecting differences in socio-economic and infrastructure-related conditions.

Table 3. **Fuel Price Elasticities of Demand for Car Use and Change of Modal Share**

		Fuel Price Elasticities	Change of Modal Share 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

In Table 4, the cross-price elasticities of demand for passenger car use are estimated through the sample enumeration technique. The fare cross-price elasticity ranges between 0.016~0.084, which shows an inelastic behaviour. Also, a modal shift from car to mass transit with a 50% fare decrease result in at most 4.35%. From this, we can expect that implementing policy for subsidising transit fares will not bring about a significant reduction in car usage.

Table 4. **Fare Elasticities of Demand for Car Use and Change of Modal Share**

		Fare (cross price) elasticity	Change of Modal Share 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

Table 5 shows the change in modal share due to an increase in the parking fee. When the monthly parking fee increases by US $33.00, car use decreases by 13~15%. Similarly, when the monthly parking fee increases by US $66.00, car use decreases by 25~30%. Because current individual levels of parking fee are not all the same, the cross-price elasticity of parking fees cannot be estimated.

Table 5. **Change of Modal Share due to Increasing Parking Fee**

			Modal share before and after the change of parking fee	Change of modal share (%)
+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

The cross-elasticity of the in-vehicle transit time for car use demand can be estimated using the sample enumeration technique. When the in-vehicle transit time is decreased by 10~50%, the cross-elasticity ranges between 0.46~0.57. Moreover, when subway speed improves by 50%, 29% of car users will transfer to the subway. Introducing either an express subway transit system or an express bus service will therefore be an effective policy for reducing car use and traffic congestion in Seoul if there is not much latent demand for car use. The result of the cross-elasticity in-vehicle transit time for car use demand is shown in Table 6. The subtle differences in elasticities in Tables 6 and 7 reflect sample enumeration related errors.

Table 6. **In-vehicle Time Elasticities of Demand for Car Use and Modal Share**

		In-vehicle (cross) time elasticity of demand for car use	Change of modal share 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

The cross-elasticity of out-vehicle transit time for demand of car use can be estimated using the sample enumeration technique. The cross-elasticity of out-vehicle time is lower than that of the in-vehicle time. As shown in Table 7, when the out-vehicle transit time decreases by 10~50%, the cross-elasticity ranges between 0.19~0.38 and the modal shift from car to transit modes can change by up to 19%. If a policy aimed at increasing the frequency of bus and subway services were to be implemented, it would be very effective in promoting the use of transit modes and reducing traffic congestions in Korea.

Table 7. **Out of-vehicle Time Elasticities of Demand for Car Use and Modal Share**

		Out-vehicle (cross) time elasticity of demand for car use	Change of modal share 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

In this study, the level of service in transit modes is defined as the level of crowdedness. As shown in Table 8, when the congestion of transit modes decreases by one step, defined as the possibility of securing a seat in crowded public transit, 18~25% of car users will transfer to alternative modes. Moreover, improving in-vehicle congestion is very important for promoting the use of transit modes and reducing traffic congestion in Seoul.

Table 8. **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

By utilising elasticity estimates, we were able to analyse the effects of hypothetical TDM policies in terms of modal shifts. As a result, we determined that fuel price policy and fare-related policy had very limited impacts and were very ineffective policy measures. On the other hand, there were many effective policy measures such as parking regulations, pricing policies related to parking, express buses, express urban trains and HOV lanes. In addition, reducing crowdedness in bus and subway by increasing the frequency of public transit services is also an effective policy measure.

The results of the empirical analysis given above suggest which policy intervention measures would be effective in revitalising public transport use in the Seoul metropolitan region. These include providing faster and more frequent services and increasing the amenity level of public transport. The following sections describe how these policy measures have been implemented in Seoul.

3. SEOUL'S PUBLIC TRANSPORT SYSTEM

Seoul is the capital of South Korea with a population of approximately 10 million inhabitants living in an area of 605.2 km2 and with a GRDP (Gross Regional Domestic Product) of 283,651 billion won (based on 2011 figures). Although the Seoul area accounts for merely 0.6% of South Korea's total surface area, it contains 20.1% of Korea's entire population. The SMA (Seoul Metropolitan Area) includes Seoul, Incheon and Gyeonggi and has a population of 26.6 million (49.3%), covering an area of 11,818 km2, and has GRDP of 585,979 billion won (based on 2011 figures).

A study was conducted to observe the urban sprawl of the SMA over two periods of time. Between 1989 and 1996, 5 towns and 292, 000 houses were built in an area of 50.1 km2, accommodating a population of 1.17 million. Between 2001 and 2012, a further 12 towns and 671,000 houses were built in an area of 146.1 km2, accommodating a population of 1.75 million. Although the periods were of differing durations, the rate of urbanisation was higher in the second period than in the first.

Figure 1. **Trends in Urbanisation in the Seoul Metropolitan Area**

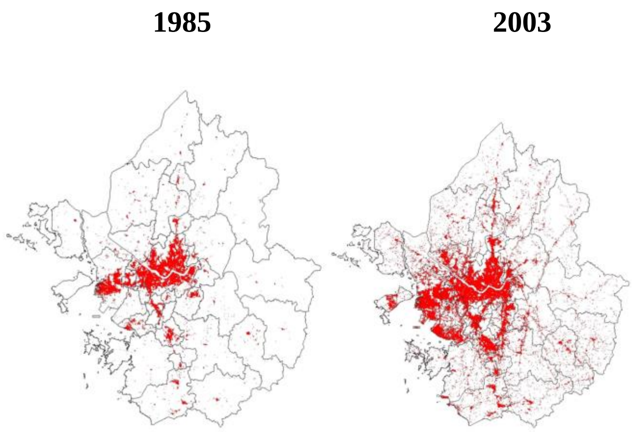
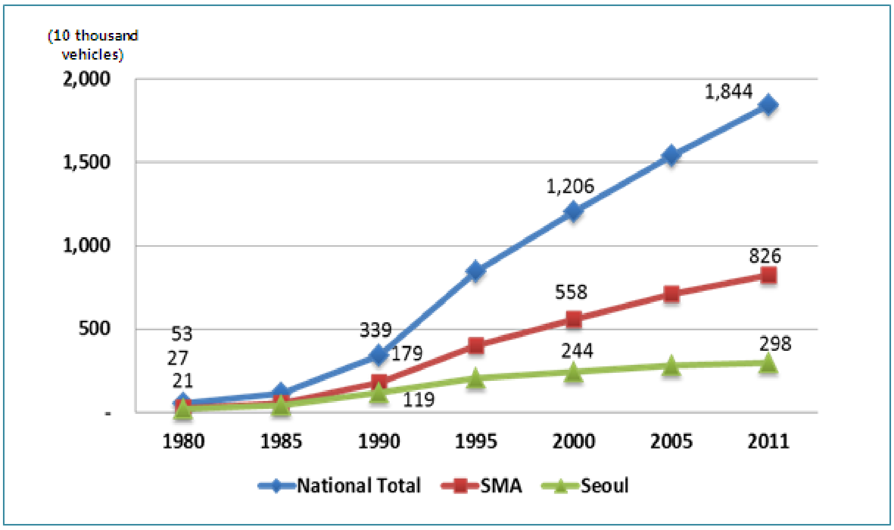


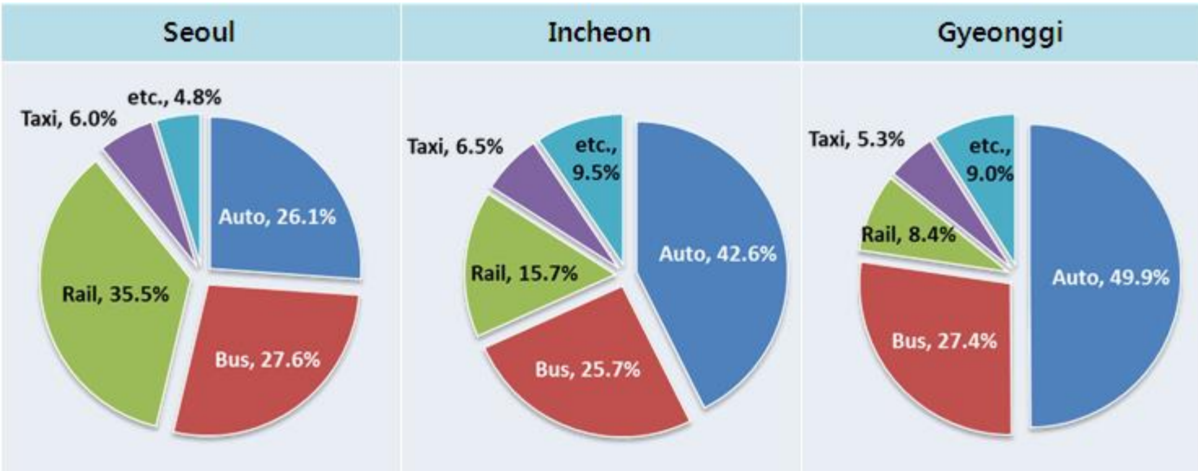
Figure 2. **Trends of Vehicle Registration**



The above figure illustrates the number of vehicles registered in Seoul, the SMA, and the Republic of Korea for specific years. As a city develops and becomes increasingly urbanised, more people will be attracted to move there to experience a higher standard of living compared to rural areas. This trend is also closely linked to the increase in the number of new vehicle registrations. In 2011, for example, the number of vehicles registered per person in Seoul increased from 0.02 in 1980 to 0.3.

The SMA has some of the most highly developed transport infrastructure in Korea. The SMA has some 24,070 km of road, 3,694 bus routes (26,847 vehicles), and 825.2 km of railway lines (521 stations). Although Seoul takes up a small proportion of land area in the SMA, its transport infrastructure comprises about 8,199 km of road, 447 bus lines (9,340 vehicles), and 346.3 km of railway lines (321 stations).

Figure 3. **Mode Share for Each SMA Region**



The Seoul Metropolitan Transportation Authority has conducted a study to determine transport conditions in the major regions in the SMA. Seoul accounts for approximately 20.011 million of the 49.660 million intra-city trips per day in the SMA. As shown in the figure above, the majority of people in Seoul make use of the well-developed public transportation network. The congested traffic conditions in Seoul make subways and buses the most viable options. In contrast, a higher proportion of people in Incheon and Gyeonggi use private cars.

4. SEOUL PUBLIC TRANSPORT REFORM ACHIEVEMENTS

The reform of Seoul's public transport system had two main objectives: firstly, to increase the speed and punctuality of bus services, and secondly to integrate all modes of public transport. The speed of bus services was increased by installing exclusive median bus lanes. The integration of public transport services called for the semi-public provision of bus services and introduction of an integrated public transport fare which allows strictly distance based fares regardless of the number of transfers involved. These policy measures were generally in line with the policy implications derived from our quantitative studies of policy instrument effectiveness.

Infrastructure Development

Although Seoul's transport infrastructure is relatively advanced compared to other cities in Korea, several development projects can help to improve the quality of transport services and infrastructure. First, the upgrading of existing railway lines in Gyeonggi-do, Incheon, and Gangwon-do not only relieves congestion in Seoul, but also helps the spread of Seoul's population. As the concentration of people and economic activities has increased in the Seoul Metropolitan Area, dispersion and balanced regional growth have been major policy objectives in Korea. Furthermore, expanding the capacity and electrification of train services allows more efficient operations. Last, constructing new lines in Ansan, Gwacheon, Ilsan, Bundang, and Pangyo helps to support new town development. The lines connected to Seoul can also help improve traffic conditions. New lines are financed by levying development charges.

Semi-Public Bus Operation and Integrated Fares

The need to reform public transport services was clear from the vicious circle in which bus services found themselves. The increasing number of vehicles on the roads and lack of bus priority policies, such as bus lanes and subsidies, were responsible for the poor punctuality, lack of reliability and slow speed of bus services. The resultant operating conditions and congestion generated stress in bus drivers, which could lead to unfriendly services and traffic accidents. Moreover, limited road capacity and congestion also resulted in routes being abandoned, periodic increases in fare and labour disputes. Since routes were owned by private bus companies, it was difficult to adjust routes to demand. As a result of reduced operations and increased fares, the number of bus users had decreased, resulting in cuts in bus services, reductions in staff levels and the bankruptcy of bus companies.

In order to address the above issues, the Seoul Metropolitan Government proposed and implemented the following reforms of the transport system.

A new revenue system and main routes bidding system were introduced for bus services. While the previous revenue system was based on the number of passengers, this new system is based on the distance covered by services (veh-km). Furthermore, these revenues are jointly managed.

The new bus network lines are colour-coded according to the type of service they are designed to provide. Blue lines are trunk lines linking suburbs to the downtown area at the regional level. Trunk lines also provide fast and punctual services. Green lines are feeder lines feeding into trunk lines and the subway network in order to meet local traffic demands. Yellow lines are circular lines providing local services within the downtown area. The circular lines are mainly designed for business and shopping trips. Lastly, red lines provide services at the level of the metropolitan area as a whole by providing express connections between satellite cities and the downtown area. Metropolitan area lines also help to provide alternative transport for passenger car commuters. The following two figures illustrate the situation before and after creation of the new networks.

Figure 4. **Trunk & Feeder Bus System**

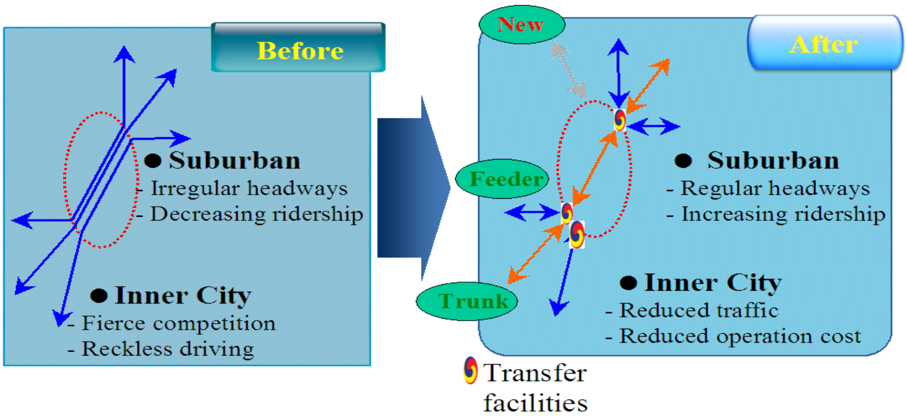
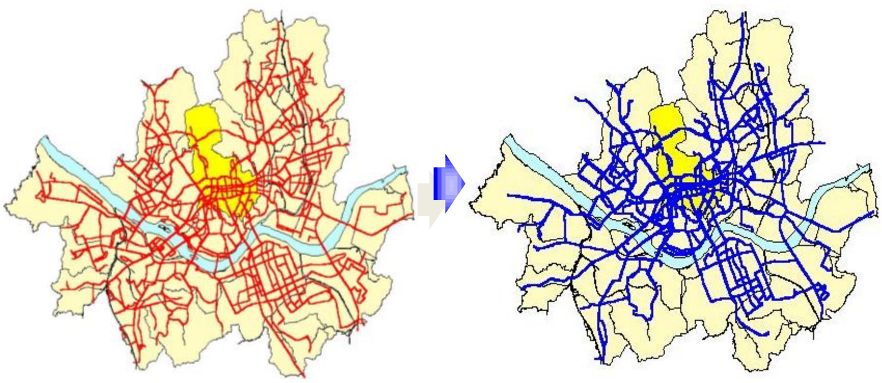


Figure 5. **New Trunk & Feeder Network**



Seoul has introduced distance-based fares for its public transport transits. For single subway trips, a basic fare of 1,000 Korean won (1 US Dollar) is charged for trips of up to 12 km and an extra fare of 100 Korean won added for every additional 6 km. In the case of single bus trips, users pay a single fare of 1,000 Korean won. For trips involving transfers, Korea's public transit system utilises a cumulative distance-based fare system. Transferring between subway lines is free of charge. A basic fare goes up to 10 km and an extra fare is paid for every additional 5 km.

Bus Management/Information System

Figure 6. **Bus Information Service**

Seoul TOPIS (Transport Operation & Information Service) provides real-time information on bus operations through the ARS, the Internet, mobile applications and bus shelters. Bus information, such as real-time location, the interval between buses, arrival times, routes and transfers, can be easily accessed by both passengers and bus companies. Bus companies use this information to manage bus services efficiently.

Infrastructure: Exclusive bus lane, Station Improvement

Exclusive bus lanes allow faster and more reliable bus services to be provided within the SMA's service area. In 2011, there were 157 km of bus lanes installed along 13 corridors. Furthermore, the introduction of exclusive median bus lanes also helped to improve the efficiency of bus operation. As a result, it has attracted patronage from private vehicles and increased the number of bus users.

Figure 7. **Exclusive Median Bus Lane**

Figure 8. **Bus Stop Improvement**

As shown in the figure above, bus stops have been drastically improved. Shelters and fences have been installed to provide bus users with a suitable area in which to wait. In addition, some bus stops display real-time bus information so that users know exactly when the next bus is coming.

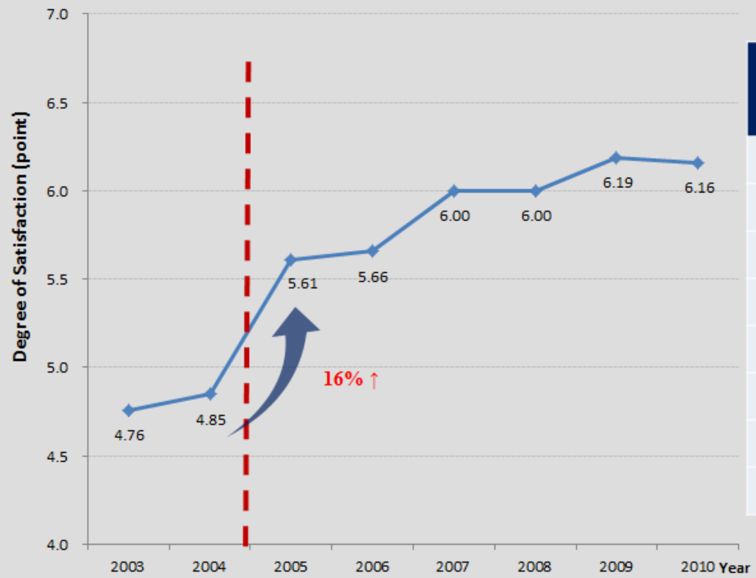
5. SUMMARY AND RESULTS OF THE REFORM OF PUBLIC TRANSPORT SERVICES

Empirical studies of public transport in Korea suggest that improving the attractiveness of services by reducing travel times and improving amenities can strongly increase public transport patronage. Travel time related attributes are estimated to be more important than monetary attributes in the Seoul metropolitan region. As people are accustomed to high amenity levels in private transport they tend to require more amenities in public transport services. Empirical evidence of this thesis in Korea can be found in Lee *et al* (2003).

Figure 9. **Increase in Public Transport Patronage**

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

Figure 10. **Trend in Citizens' Satisfaction with Transit Services**



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

The reform of public transport in Seoul can be regarded as a success. The reform was well received by citizens and was also benchmarked in many other cities in Korea as well as in other countries.

Bus ridership actually increased by about 14% after the reform, reversing the earlier trend decline. According to an official survey, public satisfaction with the Seoul public transport system also jumped by 16% after the reform. Bus users rated increased punctuality and shortened travel times as highly effective factors in encouraging people to switch to public transport. The introduction of distance-based integrated fares was another important element of the reform, as it also enhances the attractiveness of public transport.

The results of public transport policy reform are consistent with ex ante empirical analysis outcomes. These suggest that empirical studies can play a practical role in predicting hypothetical policy measures effectiveness with a reasonable degree of accuracy.

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International Transport Forum
2 rue André Pascal
75775 Paris Cedex 16
itf.contact@oecd.org
www.internationaltransportforum.org