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Analysis of travel patterns between road and transit-oriented development areas

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SUMMARY

The objectives of this study are to analyze the travel patterns based on social changes between 1996 and 2002, and then to identify main implications in transport policies in the Seoul Metropolitan Area (SMA). In SMA, there are many changes during 6 years. For example, SMA has changed the paradigm of transportation policy from car-oriented policy to public-oriented policy. So, this study examines the general travel pattern changes in the SMA and compares the travel patterns of regions invested in road construction (road-invested areas) with those of regions invested in transit (transit-invested areas). Study results show that while road investment had little effect on reducing congestion, the number of cars decreased in transit-invested areas due to the modal shift to transit modes. This study suggests that transit-oriented policies should be utilized as a solution to overcome severe traffic congestion. Copyright © 2010 John Wiley & Sons, Ltd.

KEY WORDS: Downs-Thomson's paradox; travel pattern analysis; transit-oriented development; median bus lane; Seoul metropolitan area

1. INTRODUCTION

Because of rapid economic growth, urbanization started in Seoul in the 1970s and has sprawled toward Kyunggi province and Incheon city, surrounding Seoul since the 1990s. As a result, the concentration of population has grown not only in Seoul but also in Kyunggi province and Incheon city. Now, the population of the Seoul Metropolitan Area (SMA), including Kyunggi province and Incheon city, has reached about 20 million, that is half of the Korean population. Consequently, traffic congestion has greatly worsened in the SMA. In an attempt to mitigate traffic congestion in the SMA, the Seoul Metropolitan Government (SMG) has implemented Traffic Demand Management (TDM) policies such as maximum parking requirements, congestion toll collections, parking cost increases, etc. However, traffic congestion in the SMA has worsened. Now, the SMG is worried that its international competitiveness is being dulled and that sustainable development is not possible any longer because of increasing congestion costs and the resulting increases in freight rates.

Against this backdrop, the SMG has been changing transportation policies from auto-oriented to transit-oriented since 2003. In particular, the SMG is focusing on developing a public transport network, consisting of buses and subways, as its principal transport system. The integration of public transport modes takes priority in encouraging modal shift and discouraging auto use. In addition, the SMG eliminated the Chunggye urban expressway, which was an important link connecting southern Seoul with the downtown area, and the downtown area with eastern Seoul. In this context, these missing links could bring about negative influences to the overall network. Therefore, transit-oriented policies should be considered as a solution to improve this situation.

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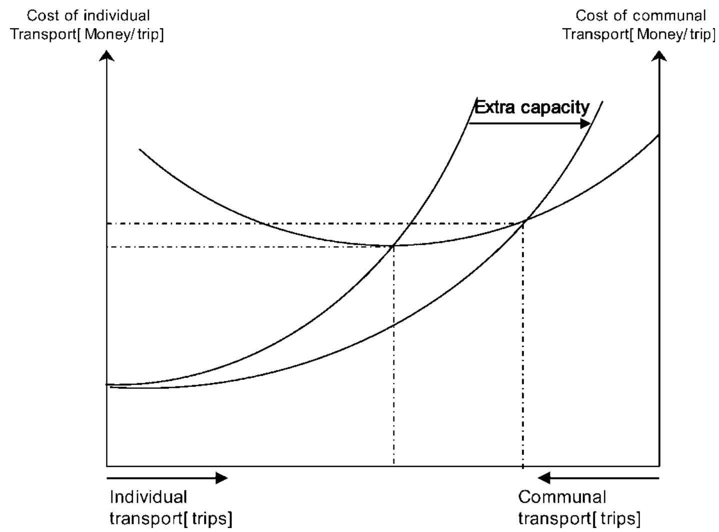

Figure 1. Downs-Thomson's paradox.

The objective of this study is to analyze travel patterns based on social changes between 1996 and 2002, and then to propose main directions in transport policy in the SMA. Firstly, we begin with a review of the existing studies, then analyze the travel patterns and finally suggest transport policy directions for the SMA.

2. EXISTING STUDIES: DOWNS-THOMSON'S PARADOX

In the seminar paper on the "Law of Peak-Hour Expressway Congestion," Downs [1] claimed that the suppressed demand for private transportation would immediately fill any added freeway capacity. One type of suppressed demand discussed was made up of transit users who would change modes when the roadway system was improved. The loss of transit patronage would cause a loss of revenue for the transit operator, who, in the absence of increasing subsides, would raise fares or cut service. The resulting deterioration of transit service would cause even more people to switch modes, causing further congestion on the road facility. This is commonly called the "Downs-Thomson's Paradox."

Mogridge *et al*. [2] extends this idea to the Downs-Thomson's paradox as shown in Figure 1 whereby road capacity increases can actually make overall congestion on the road worse. This occurs when the shift from pubic transportation causes a disinvestment in the mode such that the operator either reduces frequency of service or raises fares to cover costs. This shifts additional passengers into cars. Ultimately the system may be eliminated and congestion on the original road will be worse than before. Arnott and Small [3] provide a mathematical example of this effect.

New capacity does not cause only mode shift (from pubic transport to car) but also induces more frequent travel. Goodwin [4] provides a review of some of the historical evidence in the UK going back to a report done for the UK Ministry of Transport in 1938 that evaluated a significant increase in traffic on a new road. Cairns *et al*. [5] studied responses to changes in the goals of transportation policy in the UK (to find ways of supporting alternative modes of travel while reducing total vehicle traffic levels).

3. TRAVEL PATTERN ANALYSIS IN THE SEOUL METROPOLITAN AREA

3.1. General travel pattern analysis in the SMA

In 1996 and again 2002, the SMG carried out household travel surveys on 150 thousand households in the SMA. According to the survey results, the number of daily trips increased by 15.4% from 47.3 to 54.5 million as indicated in Table I. However, interpretation of these results is affected by changes in demographics and modes of travel. To begin with, daily trips in Inner Seoul decreased by 3.2%, while those in Outer Seoul and between Inner and Outer Seoul increased by 41.6 and 33.1%, respectively.

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Table I. Number of daily trips in the SMA in 1996 and 2002 (trip/day).

	Seoul ↔ Seoul	Seoul ↔ Outer Seoul	Outer Seoul ↔ Outer Seoul	Total
1996	21 610 485	6 189 075	13 609 281	41 408 841
2002	20 914 466	8 765 810	18 109 450	47 789 726
Change (%)	−3.22	41.63	33.07	15.41

Note: Walking trips are excluded.

Table II. Number of auto trips in the SMA in 1996 and 2002 (trip/day).

	Seoul ↔ Seoul	Seoul ↔ Outer Seoul	Outer Seoul ↔ Outer Seoul	Total
1996	4 656 268	2 172 956	5 294 134	12 123 358
2002	5 032 507	2 950 325	7 758 070	15 740 902
Change (%)	8.08	35.77	46.54	29.84

Table III. The change of mode share in the SMA in 1996 and 2002.

	Auto (%)	Bus (%)	Subway (%)	Taxi (%)
1996	25.7	21.2	11.4	8.9
2002	28.9	16.6	12.3	7.3
Change (%)	12.5	−21.7	7.9	−18.0

The number of auto trips is rapidly increasing because of auto industry growth as indicated in Table II. In particular, the increase in number of trips in Outer Seoul (46.54%) and into/out of Seoul (35.77%) was much larger than that of Inner Seoul (8.08%).

The mode share rates of buses and taxis decreased as indicated in Table III, while those of subways and autos increased. And, in terms of increase rate, the car rate was higher than the subway rate.

3.2. Travel pattern analysis in the road-invested area

Since the 1990s, Seoul has sprawled across the Kyeongbu expressway located in southeastern Kyunggi as shown in Figure 2. In particular, Bungdang new town, which is located 40 km away from

Figure 2. Study area: Seoul, southeastern Kyunggi and Kyeongbu expressway.

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Table IV. Comparison of Seoul with southeastern Kyunggi: population, road length, the total number of cars, the number of cars per person.

		Seoul	Southeastern Kyunggi
Population	1996	10 466 707	1 938 906
	2002	10 280 523	2 364 945
	Change (%)	−1.78	21.97
Road length (km)	1996	7674.67	1260.33
	2002	7888.77	1592.83
	Change (%)	2.79	26.38
The number of registered cars	1996	1 704 793	222 050
	2002	1 786 720	307 355
	Change (%)	4.81	38.42
The number of registered cars per person	1996	0.16	0.11
	2002	0.17	0.13
	Change(%)	6.70	13.48

southeastern Seoul has expanded very rapidly. Naturally, traffic conditions in these areas are getting worse and worse. So, the SMG and the Government of Kyunggi have constructed new roads in these areas to relieve traffic congestion.

Table IV shows the changes in Seoul and southeastern Kyunggi between 1996 and 2002. Firstly, the population of Seoul decreased by 1.8% while that of Southeastern Kyunggi increased by 22%. Secondly, in Southeastern Kyunngi, the road length increased by 26.4%, which is 10 times larger than Seoul in terms of change rates. Thirdly, the number of registered autos increased by 4.8% in Seoul and 38.4% in southeastern Kyunggi.

As the increased road length in Table IV shows, the Kyunggi Government has invested heavily in road construction which connects Seoul and southeastern Kyunggi to relieve the congestion problem on its side. However, this road supply was not as effective as expected; rather it encouraged people to own their own cars which, in turn, added new traffic from the latent demand. In reality, the increased rate in the number of autos per person in the southeastern Kyunggi area is twice as high as Seoul. As a result of this fact, the number of auto trips in 2002 increased by 35% compared with that of 1996, and the travel time of cars scarcely decreased. On the other hand, the number of bus trips scarcely increased and the travel time of the buses increased.

3.3. Travel pattern analysis in the transit-invested area

Unlike the Kyunggi Government, the SMG has continuously constructed subways to solve the same problem, traffic congestion. The Seoul subway system now consists of eight lines and the total length is about 287 km, which is almost twice as long as the 148 km that existed in 1995. Figure 3 shows the subway network of Seoul and the added line since 1996 in bold.

The newly-built lines since 1996 are lines no 5, 6, 7, and 8, which are located in rapidly changing areas of land use in Seoul. The SMG had to supply transportation systems in some form, so it picked the subway system as its answer. This study examined the changes in traffic counts in the area where new subway lines were added. The results in Table V show that, while total trips decreased in Seoul between 1996 and 2002, they increased by 23% in the subway-added areas. In detail, auto and subway use increased while there was only a narrow change in bus use. Such a change is apparent and meaningful when compared to travel patterns of Seoul in general. In reality, total trips in Seoul decreased, while auto trips increased. However, in the case of transit-invested areas, travel patterns are quite different. The increase in the rate of auto trips in these areas is similar to that of the total trips in Seoul. However, the increase in the rate of subway trips is much higher. The number of bus trips did not drop in transit-invested areas while total bus trips were on the decrease in other areas. Judging from these results, it is fair to say that such an investment in transit facilities stops sharp increases in auto use and boosts the use of transit systems.

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Table V. Number of trips, and travel time between Seoul and southeastern Kyunggi.

		Car	Bus
Number of trips	1996	445 874	280 834
	2002	599 774	289 755
	Change (%)	34.52	3.18
Travel time	1996	61.7673	58.1788
	2002	57.5156	58.6554
	Change (%)	−4.25	0.48

4. TRANSPORT POLICY DIRECTIONS OF THE SMA

As shown in previous sections, travel patterns were very different according to the focus of transport policies. That is, in cases where road investment was made, the number of total auto trips increased due to better road environments, while reduction of travel time was not successful when compared to the investment cost. Rather, travel time increased. On the other hand, in cases where transit investment was made, the number of transit trips increased much higher and the number of bus trips did not drop in transit-invested areas while total bus trips were on the decrease in other areas as indicated in Table VI.

In order to divert auto users into transit modes in areas such as Seoul and Kyunggi where the number of auto trips has skyrocketed, it is necessary to make intensive investment in transit facilities. For example, when the SMG transformed the bus system into a trunk-feeder line system and introduced the median bus lane system for trunk bus lines as shown in Figure 4, the travel speed of buses and autos improved. Figure 5 shows the locations of the truck-feeder line systems in Seoul and Figure 6 shows the operations of the truck-feeder lines systems.

The SMG [6] has introduced a "maximum space car parking restraint" policy, which reduces the existing parking supply requirement from 40 to 20% for new commercial and office buildings built in the downtown area. This policy has not had a great impact since the downtown area has already been developed substantially, which means that not many new buildings have been constructed since the

Figure 3. Seoul subway map.

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Table VI. Traffic changes in transit-invested areas.

		Total mode			Car		
		1996	2002	Change (%)	1996	2002	Change (%)
Sphere of influence	Line 5	1 221 465	1 438 438	17.76	319 584	387 976	21.40
	Line 6	500 037	573 590	14.71	106 317	127 592	20.01
	Line 7	1 172 137	1 418 984	21.06	250 706	305 517	21.86
	Line 8	649 049	800 802	23.38	192 858	237 233	23.01
Seoul		21 610 485	20 914 466	−3.22	4 656 268	5 032 507	8.08

		Subway			Bus		
		1996	2002	Change (%)	1996	2002	Change (%)
Sphere of influence	Line 5	107 931	194 979	80.65	338 487	337 988	−0.15
	Line 6	23 727	89 832	278.61	220 275	262 345	19.10
	Line 7	100 873	201 427	99.68	345 240	357 972	3.69
	Line 8	33 218	91 975	176.88	172 609	166 815	−3.36
Seoul		6 116 277	7 178 286	17.36	6 955 923	5 977 054	−14.07

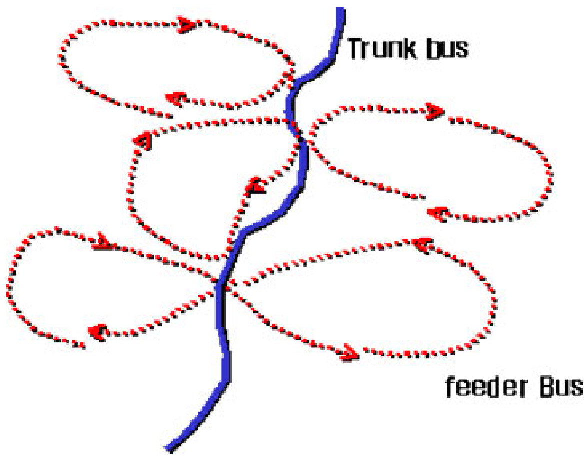

Figure 4. Trunk-feeder line system.

new policy came into effect. As a result of this, the SMG [7] plans to reduce on-street parking spaces on a gradual basis.

Since 1996, the SMG has started charging around one and half US dollars as a tunnel congestion fee against autos using Namsan No. 1 and 3 tunnels, which connect southern Seoul with the downtown. This pricing system was successful in reducing 24% of traffic volume for several years after its introduction, and it also resulted in an increase in the travel speed from 21.6 to 33.6 km/h. However, the impact has gradually weakened and the reduction rate of traffic volumes has dropped by 13.6% after 2 years as indicated in Table VII. So, SMG has considered extending congestion charging.

Table VII. Travel speed of bus and auto in median bus lanes.

	Media bus lane route	Before (km/h)	After (km/h)	Change (%)
Bus	Case 1: Dobong, Miaro	11.0	20.3	85.0
	Case 2: Susaek, Sungsanro	13.1	22.5	72.0
	Case 3: Kangnamdaero	13.0	17.2	32.0
Auto	Case 1: Dobong, Miaro	18.5	19.9	7.6
	Case 2: Susaek, Sungsanro	20.3	21.0	3.4
	Case 3: Kangnamdaero	18.0	19.1	6.1

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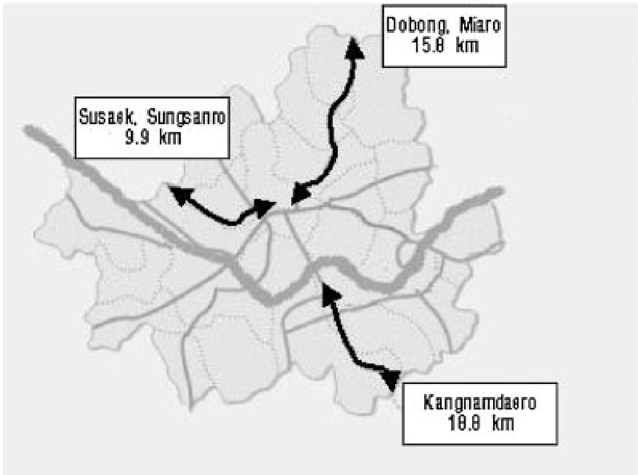

Figure 5. Location of Dobong•Miaro.

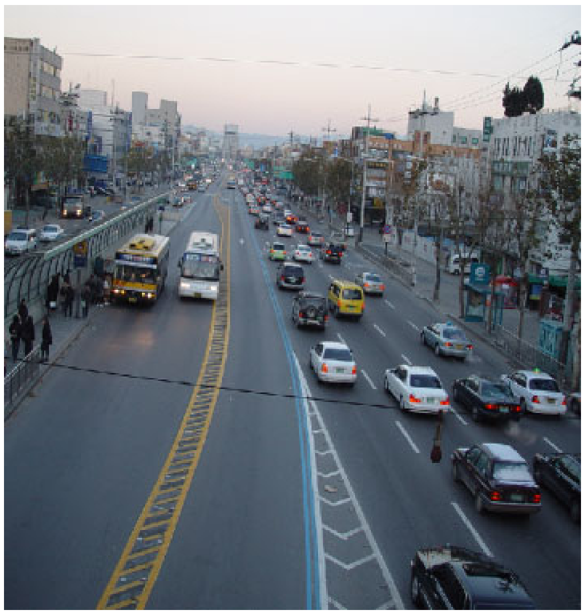

Figure 6. Median bus lane.

5. CONCLUSION

This study has analyzed the travel patterns based on social changes between the years 1996 and 2002, and then proposed main directions in transport policy in the SMA. Study results show that traffic patterns are different between road-invested areas and transit-invested areas. While there is little congestion relief in road-invested areas, auto trips have been shifted to transit trips in transit-invested areas. In this context, transit-oriented policies should be considered as a solution to mitigate severe traffic congestion as well as a careful consideration in an environmental view, which could lead to a sustainable city.

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