THE WIN-WIN SOLUTION FOR MOBILITY AND ENVIRONMENTAL QUALITY

Inwon Lee[1], Eunmi Park[2] and Joo-heon Lee[3]

[1] Professor, Department of Urban and Civil Engineering,
Hong-Ik University, Sangsu-dong, Mapo-gu, Seoul, Korea
Phone: +82-2-320-1668, (e-mail) htr@wow.hongik.ac.kr
[2] Professor, Department of Urban Engineering,
Mokwon University, San 39-1, Doan-dong, Seo-gu, Taejon, Korea
Phone: +82-42-822-7760, (e-mail) peunmi@mwus.mokwon.ac.kr
[3]Doctoral Candidate, Department of Urban Planning,
Graduate School of Hong-Ik University, Sangsu-dong, Mapo-gu, Seoul, Korea
Phone: +82-2-334-3215, (e-mail) gjhlee@wow.hongik.ac.kr

Abstract

The current increases in fuel price contribute to reducing level of congestion and air pollution. In this paper, this measure is compared with the congestion toll charge and the 10 "buje"(a 10% demand control measure of registered vehicle i.e. each vehicle can not operate when its plate's last digit matches the last digit of the date). The purpose of our study is to give a priority order to various measures and to propose the win-win solution of Seoul for policy makers. We recommend the congestion toll charge coupled with some metering measures is the win-win solution for Seoul. Also we conclude a priority order such as metering; congestion toll charge; increase in parking fee; increase in fuel price; the 10 "buje" must be acceptable for implementation. Various ITS subsystems needed to support the proposed win-win solution are identified and field operational tests for them are introduced in this paper.

1. INTRODUCTION

The rapid increases in fuel price after the IMF intervention into Korean economies has significant impact on traffic conditions all over the country. The congestion costs of six major Korean cities have been significantly reduced and the average cruising speeds in Seoul dropped to 27.5% after the fuel price increases. Based on these phenomena many argued that the fuel price increases have positive impacts on the improvement of traffic conditions and the improved traffic conditions in turn, reduce the level of the air pollution generally caused by congestion. Thus, fuel price increase is considered as a win-win solution for environmental quality and mobility. The purpose of this paper is to compare this fuel price increase with congestion toll charges, which have been successfully implemented in Seoul, and to derive the priority of each policy measures which is necessary for the better win-win solution and for the future policy making of Seoul. The suggested win-win solution of Seoul needs supports from various ITS subsystems. Field operational tests performed for these ITS subsystems are also provided in this paper.

2. EMPIRICAL COMPARISON

The basic concept of a win-win solution for environmental quality and mobility is conceptualized as shown in Figure 1. It is simply assumed that a measure of reducing emission rate by reduction of traffic volume is a win-lose solution while that without volume reduction is a win-win solution. This pre-assumption allows us to make a less complicated comparison of the fuel price increase with the congestion toll charges.

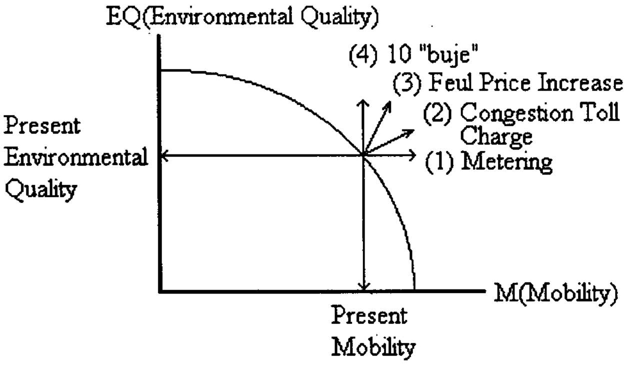

Figure 1. Conceptual Diagram for Win-win & Win-lose Solution

The level of air pollution from emission rate and traffic volume can be defined by Wakins's equation shown as below. [1]

$$C = \frac{QT}{\pi\sigma_y\sigma_z\mu}\exp\left[\frac{-y^2}{2\sigma_y^2}\right] \text{ : At Ground Level} \cdots\cdots\cdots\cdots (1)$$

Where, C : Pollutant concentration at x, y, z

Q : Pollutant emission rate

T : Traffic flow

σ : Standard deviation of plume concentration distribution in horizontal and vertical directions

μ : Wind speed

From this Wakins's equation, the level of air pollution is calculated whenever reduction of emission rate is attained by congestion management or by reduction of acceleration and deceleration. The reduction of trips is considered as the mobility reduction.

2.1 Impact of Fuel Price Increase

Many believe that the fuel price raise will reduce the level of traffic congestion and it will generate more revenues, which, in turn, will bring about more roadway investments. This belief is not true in the case of Korea. Table 1 demonstrates the level of fuel consumption before and after the fuel price raise. The revenue generated from the price increase is decreased as shown in Table 2.

Table 1. Fuel Consumption Changes before and after Fuel Price Increase

(10,000liter/day)

	December 1996			Before Increase May 1997			Increase in December 1997			Increase in January 1998		
	Gas	LPG	Diesel	Gas	LPG	Diesel	Gas	LPG	Diesel	Gas	LPG	Diesel
Seoul	46.5	10.1	126.1	57.2 +10.7	12.5 +2.3	156.7 +29.5	35.3 -21.9	7.7 -4.8	94.5 -61.2	15.4 -41.8	3.3 -9.1	40.5 -115
National Total	106.9	22.5	346.7	134.5 +27.6	28.2 +5.7	439.8 +93.1	96.0 +10.9	20.1 +2.4	314.5 -32.2	54.3 +52.6	11.2 +11.3	179.3 +167.4

Source : 'IMF Impacts on Traffic Situation', Korea Transportation Institute, January 1998

Table 2. Generated Revenue Changes after Fuel Price Increase

(hundred million won per day)

	December 1996	Before Increase May 1997	Increase in December 1997	Increase in January 1998
Seoul	8.4	10.4 +2.0	9.9 -0.4	4.6 -5.8
National Total	21.3	26.9 +5.6	30.5 +4.4	18.5 -12.5

Source : 'IMF Impacts on Traffic Situation', Korea Transportation Institute, January 1998

A very interesting pattern can be identified from these two tables. Rapid increase in fuel price has caused a sharp reduction in fuel consumption (-35% in December and -80% in January compared to the consumption level in May). This sharp reduction in fuel consumption has caused the revenue reduction to Korean government as shown in Table 2.

This phenomenon is a bit unusual in view of the demand elasticity. The demand elasticity with respect to travel cost or fuel price change is generally considered smaller than one. In other words, the revenue should be increased whenever fuel price is raised. The elasticity equation, which is commonly derived from Logit Choice Model or the singly constrained Gravity Model, provides some explanation for the relationship. As an example, demand elasticity with respect to the price change is presented the following equation:

$$E = -\beta(1.0 - MS) \quad \cdots\cdots (2)$$

Where, E : Demand elasticity

β : Cost parameter to be calibrated ($0 < \beta \leq 1$)

MS : Market share of a given mode of transportation

The cost parameter β has been calibrated many times in the studies on Korean transportation [2], [3], [4]. These studies all concluded that the value of β would be values between 0.3 and 0.6, that is, less than one with a log-linear utility function instead of simple linear utility function. Therefore, it had been expected that the revenue would eventually increase as the fuel price is raised. However, Korean government was surprised at the sharp reduction in tax revenue and consequently, reduced the fuel price up to about 20 percent in the following month. As a result, the traffic jam returned. The sharp changes are shown in Table 3 and 4. It is argued that these are only a short-term phenomenon.

Table 3. Congestion Cost Changes of Six Major Cities in Korea

(hundred million won)

	December 1996	Before Increase May 1997	2nd Increase December 1997	3rd Increase January 1998
Seoul	97.6	120.4	73.7	33.1
Busan	54.9	66.1	52.3	28.3
Daegu	14.4	18.6	16.2	7.6
Inchon	38.5	46.4	36.1	24.7
Kwangju	8.0	19.5	18.9	14.9
Daejon	26.2	31.4	25.6	18.9
Total	239.6	301.8	222.9	127.4

Source : 'IMF Impacts on Traffic Situation', Korea Transportation Institute, January 1998

Table 4. Average Cruising Speed Changes in Seoul

December 1996	May 1997	December 1997	January 1998
19.90km/h	21.51km/h	23.18km/h	27.05km/h
		16.5% increased (compare to Dec. 1996) 7.8% increased (compare to May 1997)	35.9% increased (compare to Dec. 1996) 25.7% increased (compare to May 1996) 16.7% increased (compare to Dec. 1997)

Source : 'IMF Impacts on Traffic Situation', Department of Traffic Management, Seoul City, January 1998

Table 3 and 4 show the level of congestion cost reductions in major Korean cities, and changes in the average cruising speed in Seoul, respectively. It is observed from Table 3 that most of the congestion cost savings are from Seoul. Regional centers such as Daegu, Daejon and Kwangju do not save as much as expected in percentages. These relatively small changes are probably not due to the low level of congestion in these cities (since they are already highly congested) but due to their inability to cope with the changes. In other words, these cities do not have as many alternative modes of transportation and not as many marginal trips as Seoul.

Table 5 shows the impacts of the fuel price increase work differently even on the areas within Seoul. The suburban areas show higher changes of average cruising speed (i.e. 26.7% increase) than the CBD areas (i.e. only 15.5% increase). Less congested suburban areas have bigger impacts than more congested CBD areas. However, as also shown in Table 5, the impacts on the peak periods are bigger than those impacts on the less congested non-peak periods. 41.2% of average cruising speed has been increased during afternoon peak period (from 17.98 km/h to 25.42 km/h) while only 11.2% of average speed has been improved during the non-peak period (from 24.38 km/h to 27.12 km/h). On the average, the cruising speed of Seoul has improved from 21.5 km/h to 27.05 km/h which is 25.8% increase in speed due to the fuel price increases. The congestion management measure by the fuel price raise seems working well over the time period congestion but not working well over the congested areas with heavy trip generation. Thus it may be conclude that some devices to correct this area differentiation are required for the case of fuel price increase.

Table 5. Average Cruising Speed Changes of Seoul by Area and by Time

	May 1997	December 1997	January 1998
CBD	18.57 km/h	18.89 km/h (+ 5.0%)	21.53 km/h (+15.9%)
Suburbs	21.72 km/h	23.52 km/h (+17.4%)	27.51 km/h (+26.7%)
Before noon	23.33 km/h	24.50 km/h (+18.5%)	30.43 km/h (+30.4%)
Noon	24.38 km/h	24.05 km/h (+15.1%)	27.12 km/h (+11.2%)
Afternoon	17.98 km/h	21.25 km/h (+15.9%)	25.42 km/h (+41.4%)

Source : 'IMF Impacts on Traffic Situation', Department of Traffic Management, Seoul City, January 1998

2.2 Impacts of Congestion Toll Charge

Congestion toll charges are used to locally control the traffic in specific areas, which are different from the fuel price increase. Congestion toll charges are very flexible in terms of time and space. The difficulty lies in selecting a method of toll collection and a method to determine the proper toll, if not the optimal, under various conditions. Seoul Metropolitan Government(SMG) has accepted a research result from SDI(Seoul Development Institute, a think-tank of the city of Seoul) which propose to collect congestion toll, to archive the maximum throughputs, for the most serious bottlenecks i.e. the two tunnels. This objective is different from Nash's and Else's [5], [6], [7]. Thus from the SDI suggestion, it was decided that 2,000 Korean Won is the proper level of toll charges from 7 a.m. to 9 p.m. Figure 2 shows the two tunnels, where the congestion tolls have been collected, and the detour routes. Tolls are not charged on holidays. Also passenger cars carrying more than 3 persons (car-pools), taxi, bus and truck are exempted from toll charges.

Therefore, after implementation, it is expected that more car-pools, taxies and buses would be observed during the toll hours. Volume changes by types of vehicle are summarized in Table 6. From before and after studies, it was observed that passenger cars were reduced up to 36.3% in the first stage, and then slightly increased to 29.6% one year later. Bus volume, however, increased only to 4.2% in the first stage, and then rapidly increased to 127.3% about 6 months later. Such increase in the bus volume could happen when all buses are privately owned as is the case of Seoul.

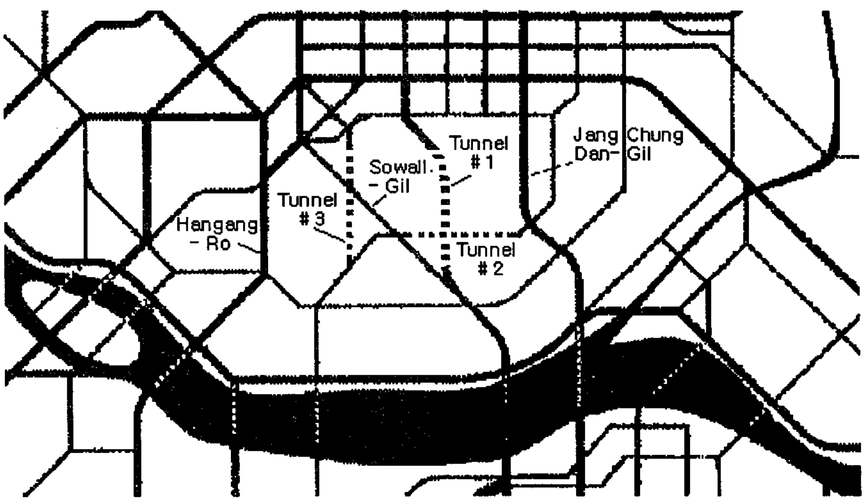

Figure 2. Map of congestion toll charge segments and detours

Table 6. Volume Changes by the Type of Vehicle before and after Congestion Toll Charge

(vehicle)

	Before Charge	Dec. 1996	Variation	Jun. 1997	Variation	Nov. 1997	Variation
Total	23,752 (100.0%)	18,682 (1 00.0%)	-21.3%	21,921 (100.0%)	-7.7%	22,428 (100.0%)	-5.6%
Passenger Car	18,628 (78.4%)	11,874 (63.6%)	-36.3%	13,170 (60.1%)	-29.3%	13,109 (58.4%)	-29.6%
Bus	792 (3.3%)	825 (4.4%)	+4.2%	1,800 (8.2%)	+127.3%	1,963 (8.8%)	+147.9%
Taxi	1,848 (7.8%)	2,938 (15.7%)	+59.0%	3,488 (15.9%)	+88.7%	3,744 (16.7%)	+102.6%
Truck	2,484 (10.5%)	3,045 (16.3%)	+22.6%	3,463 (15.8%)	+39.4%	3,612 (16.1%)	+45.4%

Survey period : 07:00～09:00 and 17:00～19:00

Source : Department of Traffic Management, Seoul City, November 1997

Table 7 shows the changes in total volume and average speed. The speeds are improved significantly in the two traffic corridors. Tunnel #1 showed 55.2% increase and Tunnel #3 showed 77.0% increase. These improvements are much better than those of the fuel price increases.

Table 7. Volume and Average Travel Speed Changes of Tunnels

		Before Charge	Dec. 1996	Jun. 1997	Nov. 1997
Total	Volume (vehicles)	90,404	67,912 -24.6%	77,377 -14.4%	78,078 -13.6%
	Speed (km/h)	21.6	33.6 +55.6%	35.5 +64.8%	29.8 +38.0%
Tunnel #1	Volume (vehicles)	39,928	30,292 -24.2%	35,423 -11.4%	34,325 -14.1%
	Speed (km/h)	23.0	35.7 +55.2%	36.3 +57.8%	29.1 +26.5%
Tunnel #3	Volume (vehicles)	50,422	37,602 -25.4%	41,954 -16.8%	43,753 -13.2%
	Speed (km/h)	17.8	31.5 +77.0%	34.7 +94.9%	30.4 +70.9%

Volume survey period : 07:00~21:00
Speed survey period : 07:00~10:00, 11:00~14:00, 18:00~21:00
Source : Department of Traffic Management, Seoul City, November 1997

Table 8. Volume and Average Travel Speed Changes of Detours

		Before Charge	Dec. 1996	Jun. 1997	Nov. 1997
Total	Volume (vehicles/h)	13,059	13,912 +6.5%	15,215 +16.5%	13,798 +5.7%
	Speed (km/h)	24.5	27.4 +11.8%	28.5 +16.3%	28.3 +15.5%
Sowall-Gil	Volume (vehicles/h)	2,958	3,448 +16.6%	3,757 +27.0%	2,838 -4.1%
	Speed (km/h)	37.8	41.2 +9.0%	26.7 -29.4%	34.3 -9.0%
Jangchungdan-Gil	Volume (vehicles/h)	2,335	2,495 +6.9%	3,796 +62.6%	3,628 +55.4%
	Speed (km/h)	22.1	21.3 -3.6%	26.4 +19.5%	27.1 +22.6%
Tunnel #2	Volume (vehicles/h)	1,338	1,374 +2.7%	1,580 +18.1%	1,656 +23.8%
	Speed (km/h)	20.8	27.3 +31.3%	38.2 +83.7%	36.5 +75.5%
Hangang-Ro	Volume (vehicles/h)	6,428	6,595 +2.6%	6,082 -5.4%	5,676 -11.7%
	Speed (km/h)	17.3	19.7 +13.9%	22.7 +31.2%	21.8 +26.0%

Volume is a average value of day, Speed survey period : 07:00~10:00,11:00~14:00,18:00~21:00
Source : Department of Traffic Management, Seoul City, November 1997

Table 8 summarizes traffic condition changes of the four detour routes. From Table 8, it is seen that both volume and speed were increased in three detours. The results were so surprising that it took a while for the Seoul Police Department to confirm. Figure 3 is prepared for those who have the equilibrium concept in their mind. Figure 3 represents that if the total demand for using private automobiles is shrunk, then travel times of the detours can also be reduced although volume of them are increased. It is argued that the backward time-volume relationship, which is commonly observed in congested roadways, can be actually happen in the detours. However, at this moment, this is just one possible explanation and not a probable one. Network simulation analysis is needed for a more rigorous validation. It is desired that further researches should be conducted for dynamic travel time and volume relationship and for latent demand modeling.

Table 9 summarizes the actual number of trips taken before and after the congestion toll charges. It is surprising to note that the number of person trips is increased while vehicle volume is decreased. Latent demand must be newly generated by various modes other than passenger cars. From this point of view, it may be said that this is a real win-win case.

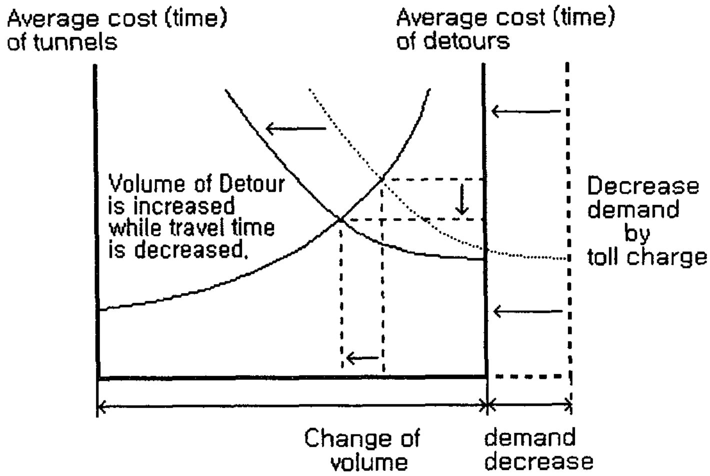

Figure 3. Effect of congestion toll charge

Table 9. Changes of Volume and Trips by Congestion Toll Charge

	Before Charge		1 year later		Variation	
	Volume per day (vehicle)	Number of trip per day (person)	Volume per day (Vehicle)	Number of trip per day (person)	Volume	Trip
Total	90,404	171,780	78,078	270,468	-13.6%	+57.5%
Tunnel #1	39,982	80,321	34,325	116,563	-14.1%	+45.1%
Tunnel #3	50,422	91,459	43,753	153,905	-13.2%	+68.3%

Average number of passenger per vehicle : passenger car 1.82 person, bus 20.2 person, others 2.23

Source : Department of Traffic Management, Seoul City, November 1997

Table 10 presents the result of the attitude survey conducted by the SMG traffic team. The team questioned 100 citizens who do not use tunnels and also questioned another 500 citizens who use tunnels. The same questions were asked to 600 citizens about what they would do if they had to pay 2,000 won. 100 citizens' state that their attitudes about the hypothetical toll charges and 500 citizens answered what they actually have done. In other words, 100 stated preference (SP) data are compared with those 500 revealed preference (RP) data as show in Table 11. It is found that in SP data, 36% answered that they could use buses but actually only 15.2% used buses. In RP data, 78.1% answered that they actually used the detours compared to only 48.1% who answered they would use detours. Therefore it is expected that there will be more diverted trips in the SP case than in the RP case.

Table 10. Attitude Survey Result on Congestion Toll Charge

Answer	Non-users of the tunnels(SP) 100 person	Users of the Tunnels(RP) 500 person
Use the detours	48.1%	78.8%
Use the public transit	36.0%	15.2%
Do car pool	13.9%	1.5%
Others (Not use the tunnels during peak hours/Abandon the travel etc.)	2.0%	4.5%

Source : Department of Traffic Management, Seoul City, November 1997

3. GRAPHICAL COMPARISON

Concept of consumers' surplus has been most widely used in transportation project evaluation. Net benefit of a project is quantified by the consumers' surplus changes with demand and cost curves. Figure 4 shows the net changes of consumers' surplus in case of 10 "buje". The demand curve is shifted downward by about 10 percent. The dotted area represents the reduction in consumers' surplus, while the shaded area represents the increase in consumers' surplus due to changes in travel time (that is, travel cost) from B to A. Therefore, the net benefit of the 10 "buje" is the shaded area minus the dotted area. As seen in Figure 4, 10 "buje" does not generate benefit as much as it is expected.

Figure 5 demonstrates the net consumers' surplus for fuel price raise. The cost curve rather than the demand curve is shifted upward. The relative difference between the shaded and the dotted areas of Figure 5 is much bigger than that of Figure 4. It is clear that the fuel price increase should be a more efficient measure than 10 "buje" for congestion management.

Figure 6 illustrates a sample case for congestion toll charges, which is different from the graphs suggested by Nash and Else. The BPR cost curve, the Logit demand curve and the volume-time relationship curve are introduced in this graph. For the analysis of congestion, queue is taken into consideration when demand exceeds the bottleneck link capacity. If demand exceeds the bottleneck link capacity, the queues in traffic network are generated to increase the travel time. Therefore, the volume-time curve is bent backward as shown in Figure 6. Queue in the system are demand minus maximum flow rate. For a given link capacity, higher demand level causes a longer queue, which will eventually reduce the maximum flow rate and increase the link travel time. This relationship is depicted in the volume-time curve [8], [9].

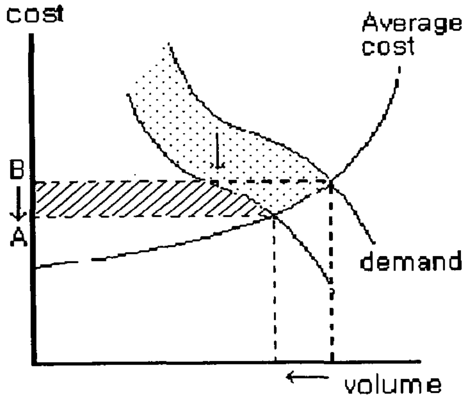

Figure 4. Change of consumer's surplus by 10 "buje"

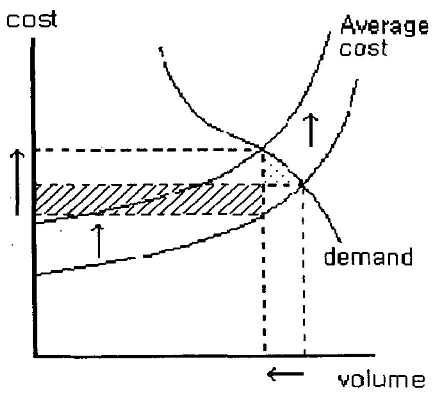

Figure 5. Change of consumer's surplus by fuel fee increase

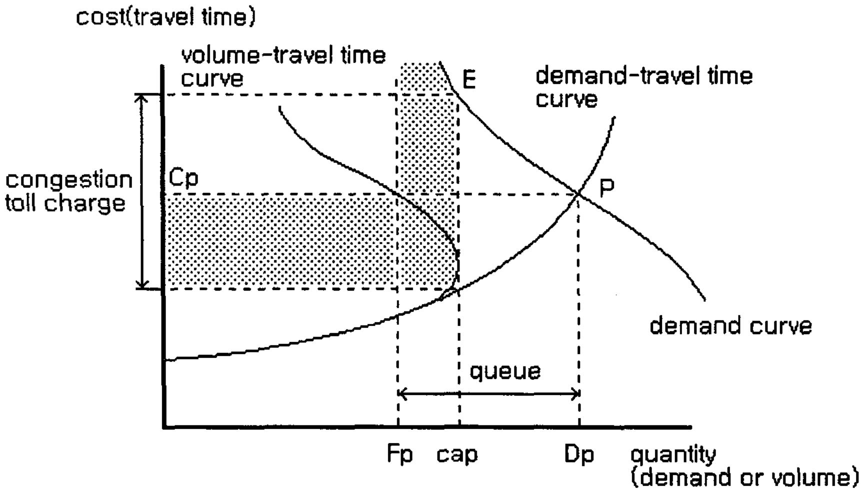

Figure 6. Relationships of cost (travel time), demand and flow
(a case of congestion toll charges)

To measure the net benefits for a given time period, it is assumed that only those who arrived at their destinations would realize their benefits. Therefore, the net consumers' surplus is defined as the dotted area in Figure 6. Major difference between congestion toll charge and the fuel price raise is noticed from Figure 5 and Figure 6. In Figure 6, the cost curve is shifted upward since the demand cannot exceed the bottleneck capacity. This is to maximize the outflow rates of the prime bottlenecks. As shown in Figure 6, if there is no congestion, there is no toll. Therefore no negative dotted area exists in case of congestion toll charges. Since the fuel price increase has even impacts on the 24 hours of a day and on the all areas of trip generation, SDI researchers recommend a parking fee increase for congested areas instead of the fuel price increase.

However, some actions should also be taken for the through traffic that contributes to congestion but does not park in the congested areas. Based on this perspective, congestion toll charge is preferred to including the parking fee increase although the latter is relatively easy to implement. All monetary measures including the parking fee increase have not only strong points of implementation but also drawbacks. One common drawback is the problem of income disparity. If the level of income cannot represent properly the relative weight of each income group, and if a shadow price exists, the monetary measures work favorably for the rich. Therefore, it is necessary to control congestion more directly and to maximize throughputs with equal opportunity.

In this sense, some metering methods seem to be promising. Metering measures can be implemented in various ways. It is thought that, among others an integrated area metering coupled with congestion toll charges, should be the win-win solution proper to Seoul. This solution's approach requires ITS supports. At this moment, overcome of the technical difficulties in implementing ITS is a key to success of the win-win solution in Seoul. In this context, SMG have been tested various ITS subsystems. The field experiences are explained in the next sections.

4. FIELD OPERATIONAL TESTS FOR ITS SUBSYSTEMS

ITS subsystems with newly emerging technologies and with little implementation experience cannot provide us a full guarantee of the stability and the performance for the win-win solution as expected. Also, Seoul Metropolitan Government (SMG) realized that it is not enough to simply expand the derived win-win solution i.e. congestion toll charge and even more important to enhance the existing system efficiency by employing various ITS subsystems. Before full-scale implementation, field operational tests have been performed for electronic toll collection system, freeway traffic management system including ramp metering subsystem, etc.

4.1 Electronic Toll Collection System

Seoul Metropolitan Government decided to collect toll for Namsan 1st and 3rd tunnels for congestion pricing, and at the same time, called proposal for non-stop toll system in December 1995. Among the 10 System Integrators submitted their proposals, SMG let 4 System Integrators set their own systems up at an unopened freeway section and had evaluated the performances of each systems for 1 month in terms of accuracy and acquisition rate of violators. 3 systems were passed and the other was failed. Now standardization of non-stop toll system of Seoul is undergoing for the successful 3 systems. However, tolls for the Namsan 1st and 3rd tunnels have been collected by cash till the standardization is completed. The expansion of the non-stop system is pending and the main reasons for the holding can be summarized as follows:

1. Difficulties in decision making
2. Lack of know-how due to little experiences
3. Reluctant to take a risk by implementing new systems with emerging technologies
4. Lack of understanding for necessity of field operational test in implementing the system with new technologies.

4.2 FTMS for the Olympic Expressway

The Olympic Expressway is one of the major arterials running from East to West along the Han River. It suffers from frequent accidents and all day long delay. A Freeway Traffic Management System for 18km section of the Olympic Expressway was implemented. Real-time traffic data are collected through 34 image sensors and 2 CCTV and processed at Kang-Nam Traffic Control Center [10]. Information is provided through various media such as 8 Variable Messages Signs, Automatic Response System, FAX, Internet etc. Beside them, RMS (Ramp Metering System) is installed at 2 sites. However, to operate the RMS needs to develop more sophisticated algorithm and to enhance the system adaptability to the field to tune up the system.

4.3 Bus Lane Enforcement System

Seoul Metropolitan Government needed revitalizing public transportation system to make Seoul a sustainable city. So the city government has been continuously expanding bus lane to encourage people to use bus. Now total length of the exclusive bus lane is 218.5 km of 61 major roadway sections [11]. The main purpose of bus lane enforcement system is to reduce labor cost and enhance the efficiency in enforcing bus lane violation. 20 video camera systems were implemented in 1995 and 4 on-line digital camera systems in 1996. To compare the performances of loop detector and image sensor, 2 loop detectors and 2 image sensors were installed along with the 4 digital camera systems. Performances of both video and digital camera systems were evaluated [12]. Stability and performance of both systems seem to be still questioning although the maintenance cost including labor cost could be seriously reduced.

4.4 ARS in TBS (Traffic Broadcasting System)

TBS (Traffic Broadcasting System) had been providing traffic information depending on the reports of about 3500 correspondents. To meet patrons' needs for the more customized personal service. TBS sought for the system that makes it possible to provide better traffic and travel information. In this context, TBS implemented

ARS (Automatic Response System) with 40 image sensors. Data are collected for 472 strategic points with those 40 image sensors. Besides the image sensors, 76 CCTV, 4 local posts, 3500 correspondents, etc are used as a source of information. In center both mechanical and manual data are processed at every 10 minutes and the processed information is transformed to voice messages. Now ARS service is provided for 21 roadways of 363 km from 7 a.m. to 9 p.m. at local call charge. Due to deficiency of image sensors, reliability and consistency of the produced information is limited. Therefore, TBS plans to expand image sensing system and makes an effort to produce more reliable information for a whole section rather than just for a spot.

It is considered desirable for TBS to get initiatives in building extensive traffic travel information system. For TBS to have initiatives, there are 3 tasks identified.

1. Building more extensive infrastructure for real-time data collection.
2. Establishing Traffic Information Center in TBS for processing the raw data and producing information and for integrating all the data and/or information produced from other ITS subsystems such as FTMS, ETC, etc.
3. The TBS Traffic Information Center supply the data and/or processed information to private sector at reasonable charge, which makes the private sector possible to produce value-added information with the supplied data and/or information. Likewise the private sector can concentrate on producing information, disseminating it by employing various media and meeting patrons' diverse demands.

5. CONCLUDING REMARKS

By reviewing the experiences of Seoul, the following conclusions are reached. Firstly, congestion toll charge and metering measures are considered superior to 10 "buje" and the increase in fuel price. Secondly, the policy priority for the win-win solution is suggested the following descending order; Metering (ATMS); Congestion Toll Charge; Increase in Parking Fee; Increase in Fuel Price; 10 "buje". Even though the analysis performed in this paper is not sufficient enough to validate this order of priority rigorously, the authors strongly feel that the suggested order of priority is worthy of note. The authors intend to continue their efforts for more rigorous validation of the priority order for win-win solution.

Finally, several field operational tests and some implementation experiences to support the win-win solution should not be dropped without any fair evaluation. Trial and errors during the tests and/or implementations would rather be valuable experiences than just fails. In this sense, all experiences should be put together and reflected in integrating the whole ITS and the win-win solution of Seoul. Experiences from other countries would be very helpful especially for SMG to implement the ramp metering system and to provide traffic and travel information.

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