FORMULATION OF STRATEGIES FOR BOOSTING THE USAGE OF PUSAN METRO SYSTEM

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Abstract: Transit agencies and companies in Pusan should admit to facing transit ridership crisis due to the ever-increasing auto use. This paper intends to suggest and evaluate the strategies that can reverse the transit ridership crisis. The strategies focus on establishing a "system" of transferring between the metro and the other transit modes, which will lead to increasing the transit ridership as well as to guarantee the fare box revenue. Two strategies, as policy alternatives, are suggested: 1) introduction of discounted fare for a transfer trip; 2) reduction in bus passenger's travel time through bus route realignment, headway adjustment etc. The evaluation of the strategies is performed to show the extent of changes in the transit riderships and resulting changes in fare box revenue. The results show that the suggested policy alternatives can adequately satisfy both transit agencies and companies in terms of ridership as well as fare box revenue.

Key words: Transit, Metro, Transfer, Fare, Bus

1. INTRODUCTION

Transit agencies and companies in Pusan should admit to facing transit ridership crisis. Constantly increasing car ownership and use have resulted in decreased use of transit system. As public transit has lost market share, not only communities have suffered from increased traffic congestion, but transit industry has lost valuable financial resources as well. The result has been the deterioration of the quality of city life and level of transit service. The pressure to increase ridership on public transit system in Pusan, therefore, has never been greater.

This is especially true for Pusan's Metro system. Over the last few years, Pusan Urban Transportation Authority (PUTA), a Metro Agency, has seen a constantly decreasing ridership.

In particular, since opening of a half section of the Metro Line 2 in July 1999, the usage of the newly opened section has been well below the expected ridership estimated by the Institute of Policy Development, Pusan Metropolitan City (IPD, 2000). Furthermore, a survey conducted by Pusan City showed that the most metro riders are captive riders, shifted mostly from bus: 85% of metro riders were former bus riders, resulting in a substantial decrease in ridership of bus system.

Besides the increasing auto use, there are many reasons for this decreasing ridership. One of major reasons, many experts argue, is an absence of convenient transfer strategies by coordinating the various transit modes in terms of routes alignments, fare structure, and schedules. If transit systems are to provide a service that permits all of their riders to travel to all of the many opportunities throughout the city area, they must implement service strategies that allow one to travel from diverse origins to diverse destinations, yet can be provided at reasonable cost. Permitting convenient transfers between different modes has been the transit industry's rational response to accommodating travel throughout a "system" of routes.

Passengers in Pusan, however, find transferring inconvenient; especially when the transit network is designed entirely independently and they have to pay every time they ride on different modes. Currently, there are no fare discounts for transfer passengers among different transit modes, and every major transit mode in Pusan is being operated entirely independently without necessary coordination among different transit modes.

This paper attempts to formulate and present the strategies that will help increase the usage of Metro system in Pusan. This study examines two possible strategies: 1) Introduction of discounted fare for transfer passengers among the transit modes; 2) reduction of passenger travel time for connecting modes to Metro system. The strategies will be designed not only to increase the ridership but also to ensure at least maintaining the present fare box revenue.

The paper will be composed of three parts: 1) description of current situation; 2) presentation of needed strategies; 3) evaluation of proposed strategies. The results of this study will present detailed strategies that can boost the usage of not only Pusan Metro System but also the transit system in general. They will be also a useful guide for restructuring the transit system as well as a base framework for further policy development for transit system in Pusan.

2. BACKGROUND

Pusan Metropolitan City, the second largest in Korea, is situated on the southeastern part of Korean Peninsular. It covers an area of 849 km^2 and houses close to 3.9 million people. To serve the population, Pusan offers a variety of transit modes with varying degree of services and fare levels, providing a comprehensive transit network that covers most of city areas. The main ones are buses, metro and taxis. They are, however, in common experiencing a crisis.

2.1 Ridership Crisis

Over the last few years, however, the transit system in Pusan should address the problem of constantly decreasing ridership. Table 1 shows the trends of daily modal shares in Pusan.

Table 1: Daily Passengers by Mode (1986-1999)

(in thousands)

Modes	1986	1991	1995	1997	1998	1999
Bus	2,903 (54.4%)	2,953 (45.2%)	2,515 (37.6%)	2,224 (35.2%)	2,009 (36.7%)	1,820 (32.6%)
Metro*	140 (2.6%)	497 (7.7%)	586 (8.7%)	623 (9.8%)	573 (10.5%)	563 (11.9%)
Taxi	1,065 (19.9%)	915 (13.9%)	1,232 (18.4%)	1,080 (17.4%)	960 (17.5%)	1,010 (18.1%)
Auto	577 (10.8%)	908 (13.9%)	1,428 (21.4%)	1,357 (21.4%)	1,080 (19.8%)	1,117 (20.2%)

Note: * Metro Line 1 only; Full operation started in 1994.
Source: Pusan Metropolitan City White Paper 1999, 2000

As one may readily see, the three transit modes have been crucial means to move people around the city area in spite of increasing auto share. Yet it can be also seen from the table that a great proportion of transit passengers has continually shifted to auto. Buses, though carrying the largest portion of travelers, have witnessed a continuous decrease in ridership, since the metro began its full operation of Line 1 in 1994.

The survey showed that 85% of current metro passengers were the former bus passengers. The metro system saw continuous increase in ridership since the opening of the first section of Metro Line 1, yet since 1997 it has also been losing its share of travelers. What is worse is that the ridership of Metro Line 2, opened in 1999, has also been well below the expected (only 30% of the originally expected figure). One must note that since 1998 total number of passengers has been decreased due to the national financial crisis, so has the auto travelers.

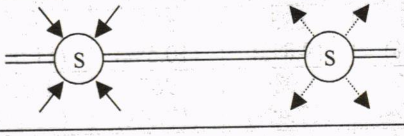
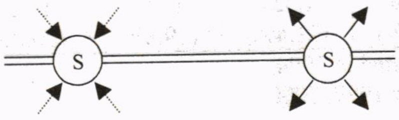
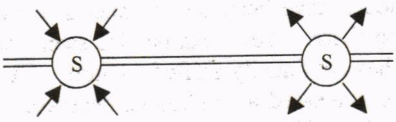
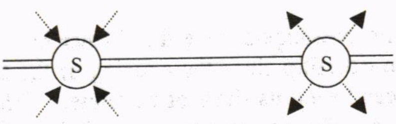
2.2 Absence of System of Transfer between Modes

Currently over 60% of daily transit passengers are Hanaro Traffic Card users. Hanaro Traffic Card system, which is composed of a system of computer network, generates a vast amount of useful information with which one can examine the situation of passenger's travel patterns and a choice of modes. From the Hanaro System, the daily transfer passengers between the Metro Line 1 and the other connecting modes – buses, feeder minibuses and taxis – and their patterns of mode choice are presented in Table 2.

It is shown that in 1999, among the 563,000 metro passengers, 16.22% passengers used the other mode to complete their trips. Specifically, 7.43% transfer to the other mode after getting off the metro, 6.89% transferred from the other mode to the metro, and 2.55% used the other modes at both starting and ending their trips. Note that 83.2% walked to and from the Metro without transferring to and from the other connecting modes. The tendency of low transfer trips between the metro and the other connecting modes is obvious from the table.

The survey conducted by Pusan City (IPD, 1999) asked bus passengers a question: "can this bus trip be also made by metro?", 37.52% of respondents answered with "Yes", 17.54% replied with" bus + metro". In other words, over 55% of bus riders in Pusan, who never use metro to complete their trips, indicated that for some reasons they are not riding metro even if they can ride or need to ride the metro.

Table 2. Transfer Pattern and Mode Share (1999)

Transfer Pattern		No. of Passengers	Connecting Mode Share
Type I		40,000 (6.89%)	Buses : 5.10% Minibuses : 1.12% Taxis: 0.76%
Type II		42,000 (7.43%)	Buses : 5.24% Minibuses : 1.19% Taxis: 1.02%
Type III		14,000 (2.55%)	Bus : 1.85% Minibus : 0.20% Taxis: 0.5%
Type IV		467,000 (83.78%)	Walk : 83.78%

Notes: Ⓢ Metro station, ═ Metro , ⟶ Connecting mode, ┈▶ Walk

Type I: ride a connecting mode before metro ride

Type II: ride a connecting mode after metro ride

Type III: ride connecting modes before and after metro ride

Type IV: do not need connecting modes (metro ride only)

For a question of why they are not riding the metro, 65.5% find transferring inconvenient and 22.8% indicate the need of fare discount for transfer trip. In other words, bus passengers pointed out an absence of system of transfer between different modes and the non-existence of discounted fare for a transfer trip.

The reasons of low transfer trips between the metro system and the other connecting modes in Pusan are many and can be summarized as following:

1. There are a number of overlapping routes between the existing metro Lines and bus lines. Basically, the two modes – buses and metro- are competing with each other, so that there are no appropriate coordination between the two modes.
2. Establishment of transfer system between the different modes through the route readjustment is difficult mainly due to a mixture of public (Metro) and private (buses) ownerships.
3. Bus passengers are suffering from the low quality of bus service resulted from circuitous and long-distance bus routes.
4. There is no fare discount for a transfer trip. Traveler should pay a full fare for each ride.

3. APPROACH TO THE PROBLEM: POLICY ALTERNATIVE

Developing and implementing strategies to boost the usage of metro system involves a number of interrelated elements. The approach to the problem in this study thus consists of a series of policy processes, which is shown as a flow-chart diagram in Figure 1.

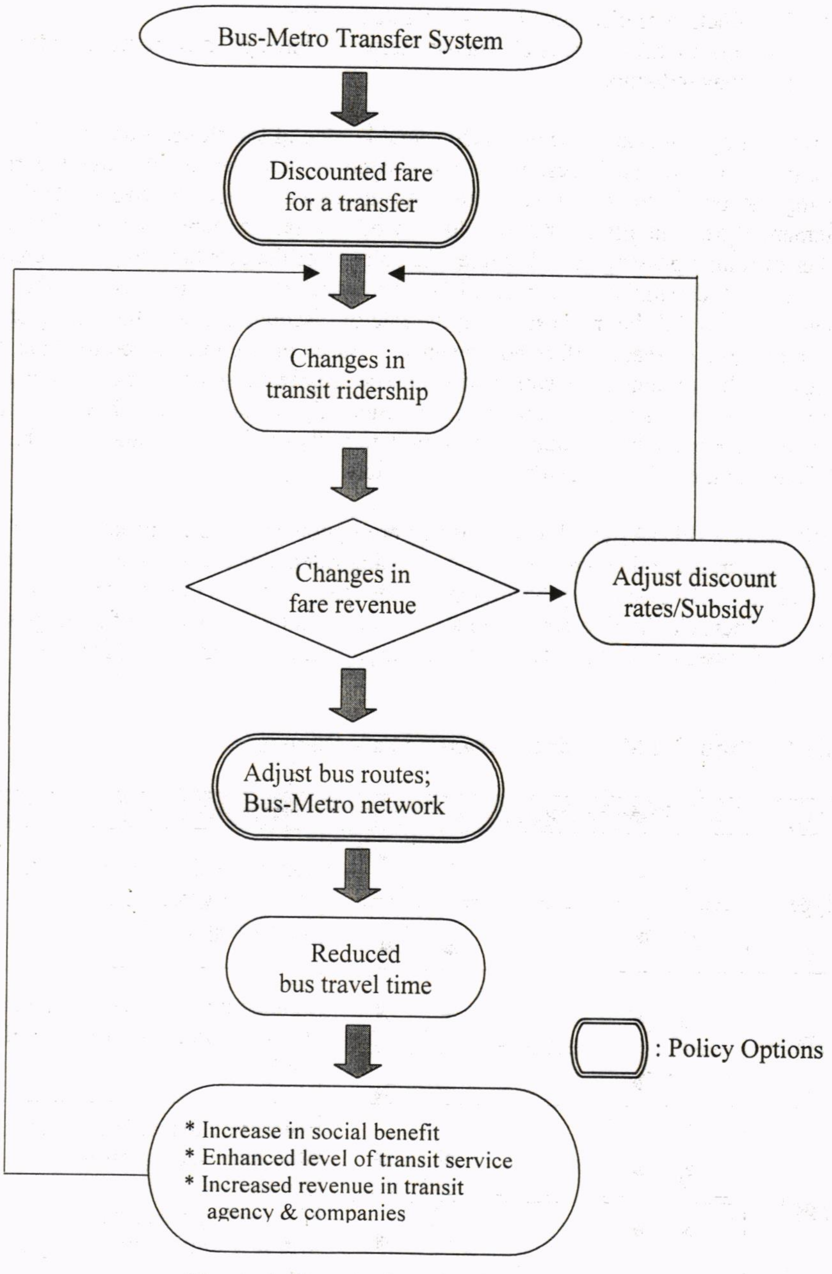


Figure 1. Approach to the Problem

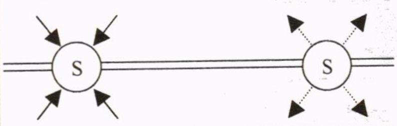
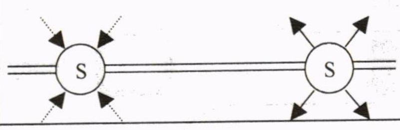
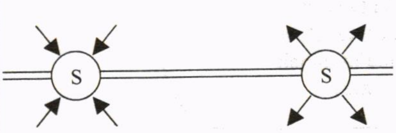
As seen in the figure, the main objective is to establish the transit transfer network. It is true that no transit network can serve all trips by direct routes without any transferring. If a transit system provides easy, simple, fast and convenient transfers, its entire network can be operated very efficiently and it can attract most potential users (auto drivers). This study proposes two strategies to achieve such an efficient transfer system:

1. Introduction of discounted fares for transfer trips
2. Establishment of transfer transit network through bus route re-adjustment and headway reduction.

The first strategy aims at reducing the financial burden of transit users and thus increasing the riderships of metro and buses, while the second is proposed to increase the ridership by reducing the bus passenger travel time. As discussed earlier, the two strategies are to be implemented sequentially. The introduction of the transfer fare discount will increase the number of transit passengers. Whether the amount of the fare box revenue increases or not, however, will depend on the rate of discount and resulting increase in the number of passengers. It will be made sure that the rate of discount is determined adequately enough to guarantee the increase in fare box revenue. Based on the guaranteed revenue, the second strategy will be implemented, which will subsequently result in additional passengers and fare revenue. The two strategies are in nature mutually exclusive, but they are implemented either independently in a sequence or simultaneously at the same time. In this study, we shall examine the effect of each strategy separately.

Transit agency (PUTA) and bus companies are opponents of the introduction of discounted transfer fare because they are afraid of decreasing riderships and consequent reduction in fare box revenue. By evaluating the strategies, this study attempts to show the result is opposite, i.e., it will increase the fare box revenue. To perform the evaluation of strategies suggested, this study focuses on the three types of transfer pattern described above (Table 3).

Table 3. Proposed Methods for Transfer Fare Discount

Transfer pattern		Proposed method
Type I		Metro fare discount within the 1 hour after getting off the connecting modes.
Type II		Connecting mode fare discount within 30-min after getting off the Metro.
Type III		Metro fare discount within the 1 hour after getting off the connecting modes. Connecting mode fare discount within 30-min after getting off the Metro.

Notes: Ⓢ Metro station, = Metro , ⟶ Connecting mode, ⋯▶ Walk

It presents the three types of transfer pattern as shown in the Table 6, which applies the different methods of discounted fare for transfer trips. The three types are proposed in order to utilize the data and information gathered by the transaction system of Hanaro Traffic Card. Hence, for the proposed methods to be implemented, all transit users are assumed to be a Hanaro Traffic Card holder, which is a contactless fare payment smart card for every transit mode in Pusan.

To predict the changes in ridership and assess the strategies proposed here, the direct and cross elasticities of changes in fare level and bus passenger travel time are needed. For this, the results of a research performed by Jung *et al.* (2000) are utilized. They developed a model of connecting mode choice for metro passengers in order to identify the influencing factors on public transit mode choice and to assess the relative importance of each analyzed factor in the choice making process.

Their multi-nominal logit model generates the direct and cross elasticities of fare and bus passenger travel time, utilizing data generated by Hanaro Traffic Card system and data by a series of SP (Stated Preference) and RP (Revealed Preference) surveys to improve the reliability of the model. The SP survey was designed to answer the questions that could not be answered by the RP survey. Both surveys were administered to a total of carefully and randomly selected 523 citizens. The RP survey is designed identify the individual characteristics and travel patterns. Using the SP method, termed stated choice technique, respondents were asked to choose among alternative modes with different attributes. And the model included such attributes as OVTT (out-of-vehicle travel time), IVTT (in-vehicle travel time), and level of transit fare. In other words, information on the effects of changes in OVTT, IVTT and fare were collected through the SP survey. On the basis of their choices, assuming the existence of a specific utility function, the value of the attributes is statistically determined. The theoretic and practical characteristics of this method are adequately discussed in a special issue of the Journal of Transport Economics and Policy (JTEP, 1988).

The elasticities of fare, IVTT and OVTT between different modes obtained from the model are presented in Table 4.

Table 4. Direct and Cross Elasticities

Mode	Connecting Mode	Fare	IVTT	OVTT
Bus	Bus	-0.0105	-0.0093	-0.0112
	Minibus	0.0184	0.0163	0.0196
	Taxi	0.0184	0.0163	0.0196
Minibus	Bus	0.0072	0.0068	0.0089
	Minibus	-0.0221	-0.0211	-0.0275
	Taxi	0.0072	0.0068	0.0089
Taxi	Bus	0.0030	0.0021	0.0023
	Minibus	0.0030	0.0021	0.0023
	Taxi	-0.0226	-0.0157	-0.0157

Notes: - direct; + cross

By utilizing the above various direct and cross elasticities, the extent of changes in number of passengers and fare box revenue can be readily computed and evaluated. However, it must be noted that the data generated by the SP survey may not represent the reality since it is based on the stated and hypothetical choice. Then the question may be how reliable the stated ones, how different the real choice will be from stated ones. In other terms, is there a hypothetical distortion? The question has no proper theoretical answer. Yet empirical tests conducted demonstrated that "individuals' stated preferences among hypothetical travel scenarios are a reasonably accurate guide to true underlying preferences". (Danielis, 2000) Jung *et al.* (2000) emphasized they made adequate efforts to enhance the quality and reliability of the data generated by the SP survey.

4. EVALUATION

The evaluation here focuses on the two issues: changes in fare discount rate; changes in bus passenger travel time consisting of in-vehicle travel time (IVTT) and out-of-vehicle travel time (OVTT). Each of strategies is evaluated separately with respect to changes in ridership and in travel time. To make analyses simplified, only a transfer between bus and metro is evaluated here, though the analyses include the transfers between the metro and the other transit modes discussed above – minibuses and taxi. The same analyses can also be readily performed for these two modes.

4.1 Fare Discount

For this analysis, the changes in ridership and revenue resulted from variations in discounted fare for transfer trip are evaluated. The discount rates are assumed to vary from 0% to 100%. Discount rates 0% indicates the present fare level. In other words, there is no fare discount for transfer passengers. 100% means the free transfer between the two modes.

The results are evaluated for each type of transfer patterns presented in Table 3, and they are numerically shown in Table 5 and graphically presented in Figures 2 and 3.

Table 5. Effects of Fare Discount on Passengers and Revenue

Transfer pattern	Discount rate (%)	Changes in transfer passengers			Changes in revenue ('000)		
		Bus	Metro	Total	Bus	Metro	Total
Type I	0	28.713	28.713	57.426	17.228	18.663	35.891
	50	43.787	43.784	87.568	26.272	14.230	40.502
	95	57.354	57.354	114.708	34.412	1.864	36.276
	100	58,861	58,861	117,722	35,316	0	35,316
Type II	0	29.501	29.501	59.002	17.701	19.176	36.877
	50	44.989	44.989	89.978	26.993	14.621	41.614
	95	58.928	58.928	117.856	1.768	38.303	40.071
	100	60,477	60,477	120,954	0	39,310	39,310
Type III	0	20.830	10.415	31.245	12.498	6.770	19.268
	50	31.766	15.883	47.649	14.294	5.559	19.853
	95	41.608	20.804	62.412	13.107	678	13.783
	100	42,702	21,351	64,053	12,811	0	12,811

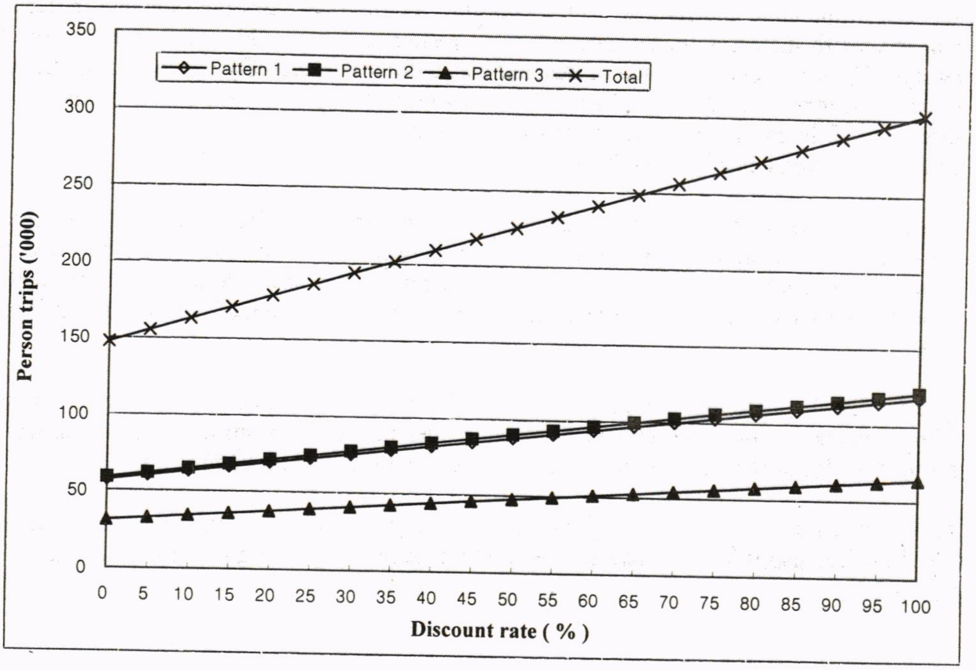


Figure 2. Number of Passengers as a Function of Discount Rate for a Transfer Trip

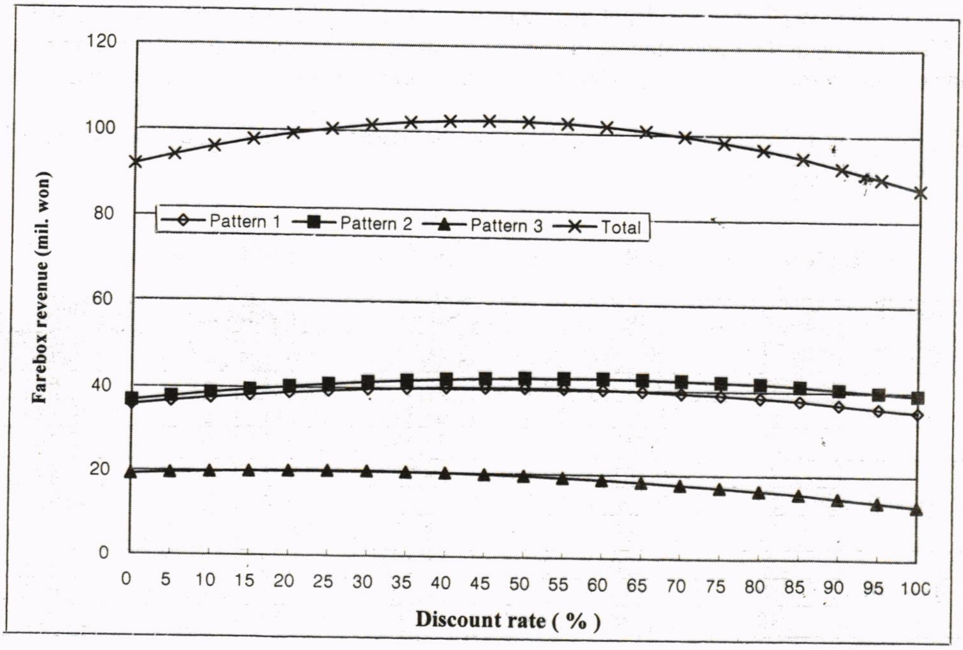


Figure 3. Farebox Revenue as a Function of Discount Rate for a Transfer Trip

As seen in the table and figures, with increasing fare discount rates the ridership in each of bus and metro increases for all types of travel pattern, as one could easily expect. Yet the changes in fare revenue for each of bus and metro differ considerably depending on the type of travel pattern. For the types I and III, bus companies enjoy increasing fare revenue as the discount rate is going up, while metro agency suffers from decreasing revenue. As for the type II, they experience the exactly opposite results.

Interestingly the analysis shows that the total revenue – the sum of revenue for bus and metro - reaches at the maximum with a discount rate of between 45% and 50%. After this rate, the total revenue decreases with increasing discount rate. It is also interesting to note that at about 95% discount rate, the fare revenue becomes the same amount of present (0%) discount rate.

One should also note that the free transfer (100% discount rate) maximizes the total number of passengers, yet the total amount of revenue does not reduce significantly. In particular, for the type II transfer the revenue increases substantially even with the free transfer.

In sum, this study shows that the fare discount strategy is able to not only increase the transit ridership, but also is able to increase the fare box revenue depending on what discount rate is to be taken.

4.2 Travel Time Reduction

The effects of travel time reduction on the transit ridership and fare box revenue are also examined. To simplify the analysis, cases of 10% and 30% travel time reductions for each of IVTT and OVTT are considered, respectively. As discussed earlier, the reduction will be achieved through the establishment of transfer network, i.e., readjustments of existing routes and circuitous routes, shortening of headways, and elimination of overlapping bus lines.

The effects of reduction in OVTT and IVTT on the passengers and revenue are presented in Tables 6 and 7, respectively.

Table 6. Effects of Reduced OVTT on Passengers and Fare Revenue

Transfer pattern	Reduction in OVTT (%)	Changes in transfer passengers			Changes in revenue ('000)		
		Bus	Metro	Total	Bus	Metro	Total
Type I	0	28.713	28.713	57.426	17.228	18.663	35.891
	10	31.914	31.914	63.828	19.141	20.744	39.885
	30	38,717	38,717	77,434	23,230	25,166	48,396
Type II	0	29.501	29.501	59.002	17.701	19.176	36.877
	10	32.790	32.790	65.580	19.674	21.314	40.988
	30	39,369	39,369	78,738	23,621	25,590	49,211
Type III	0	20.830	10.415	31.245	12.498	6.770	19.268
	10	23.153	11.576	34.727	13.891	10.124	24.015
	30	27,798	13,899	41,697	16,679	9,034	25,712

Table 7. Effects of Reduced IVTT on Passengers and Fare Revenue

Transfer pattern	Reduction in IVTT (%)	Changes in transfer passengers			Changes in revenue ('000)		
		Bus	Metro	Total	Bus	Metro	Total
Type I	0	28.713	28.713	57.426	17.228	18.663	35.891
	10	31.369	31.369	62.738	18.821	20.390	39.211
	30	36,681	36,681	73,362	22,009	23,823	45,832
Type II	0	29.501	29501	59.002	17.701	19.176	36.877
	10	32.230	32.230	64.460	19.392	20.950	40.342
	30	37,688	37,688	75,376	22,613	24,497	47,110
Type III	0	20.830	10.415	31.245	12.498	6.770	19.268
	10	22.756	11.378	34.134	13.654	7.395	21.049
	30	26,610	13,305	39,915	15,966	8,648	24,614

It is obvious that the reduced travel time has a great impact on both passengers and revenue. In particular, reduction in OVTT has a greater impact than that in IVTT, meaning that passengers are more sensitive to changes in OVTT than in IVTT with respect to the transferring between the two modes. This confirms the generally known knowledge that the elasticity of OVTT is greater than that of IVTT. With respect to the types of transfer pattern, there are no significant difference in changes of number of passengers and fare revenue.

5. CONCLUSION

Pusan City has invested a vast amount of valuable financial resource in the metro system to mitigate ever-increasing traffic problem. Yet the Metro Agency has experienced decreasing metro passengers. This study attempted to resolve the problem by suggesting the suitable strategies for boosting the metro ridership: 1) introduction of discounted fare for a transfer trip; 2) reduction of bus passenger's travel time. These two strategies have been discussed and suggested by a number of scholars and research institutes, yet the effectiveness of each strategy has not been clearly evaluated.

The analyses of this study can be summarized as following:

First, with the free transfer, the ridership increases over twice while the revenue decreases by only 5%. With the 50% discount rate, the revenue can be maximized, and with the 95% rate, the revenue becomes the same as the current level. It can be recommended that with the introduction of free transfer, the loss of revenue should be compensated by a government subsidy. In this way, the transit passengers can be maximized, shifting auto drivers to transit system.

Secondly, it showed that the reduction of bus travel time, through various service improvements including route realignments, shortening of bus headways, elimination of circuitous routes, etc, will also have a significant impact on the transit ridership and the fare box revenue. It was clear that the reduction in OVTT, through the headway shortening, would be more efficient in this respect. Hence, efforts to enhance the bus service quality associated with the system of transfer should be made, in particular to reduce the OVTT.

The results shown here may not represent the reality, since the study uses the results of the model associated with a number of assumptions and the SP data generated based on the hypothetical situation. In spite of these intrinsic weaknesses, this study clearly shows that that Pusan City should take a major action to establish a "system" of transfer between transit modes, which can be efficiently implemented, in order to improve the quality of citizens' life and that there are some of possible actions to achieve that.

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