UP School of Urban and Regional Planning

Journal in Urban and Regional Planning

journal homepage: http://journals.upd.edu.ph/ | 2015 ISSUE

Mode Shift Behavior of Bus Passengers to Rail System under Improved Rail Operations

Dilay, Germaine Ann C. and Fillone, Alexis M. ***

ABSTRACT

The PNR Line going to the Bicol Region is currently being repaired for the eventual resumption of its service. Using a stated preference (SP) survey, this research aims to describe how passengers will decide to patronize the PNR service upon its service resumption and estimate the modal shift probabilities from bus to rail service. Also, the significant factors affecting mode choice of bus passengers are determined in the survey. In the SP survey, the main factors considered are travel time, travel cost, and access time. A number of 900 bus passenger respondents originating from Manila and arriving in Naga City were interviewed for the SP survey. Results show that majority of the current air-conditioned bus passengers would shift to rail service when service performance of the latter is improved. However, non air-conditioned bus passengers are more likely to choose their current mode considering the several combinations of improved rail service factors analyzed.

Keywords: *Provincial bus service, Rail service, Mode Shift, Stated preference survey*

** Graduate Student at Transportation Engineering Division*
Civil Engineering Department Dela Salle University | germaine_ann_dilay@dlsu.ph.

***Associate Professor at Transportation Engineering Division*
Civil Engineering Department Dela Salle University | 524-4611 local 226.

INTRODUCTION

The main line south of the Philippine National Railway also known as the Bicol Express has been suspended since October 2012 due a derailment incident. It was suspended in order to give time for the rehabilitation of the tracks, which seems to be the primary issue of the Bicol Express. As part of the planning and preparation for its revival, a demand forecast is necessary. In this study, a discrete choice model of Metro Manila to Naga City bus passengers was developed. Through this model, the modal shift of bus passengers to rail system upon resumption, may be estimated. To forecast the mode shift to PNR upon its resumption, it is necessary to take note of the competitive modes available going to Naga City that may be a potential source of demand for PNR - competitive in terms of the services being offered but not limited to fare and travel time. The bus service, which includes both air-conditioned and non air-conditioned, has the highest modal split, a combined total of 87.89% of all modes available. Hence, it can be said that the bus service is the most dominant mode of transportation for Manila to Bicol travel and therefore becomes the toughest competitor of PNR.

METHODOLOGY

To start the construction of the survey forms, the comparison of the two competing modes was done and presented in Table 2. In the said table, the modes are evaluated under different scenarios of factors that include travel time, fare, frequency of travel and station facilities. All of which are seen to be critical to the decisions of the travelers when choosing a mode alternative.

Table 1. PNR vs Bus Service

Features	Bus service	PNR service
average travel time	9.5 hrs	11 hrs
frequency of travel	64 trips	1 trip
average fare	350-600 Php (non air-conditioned bus) 600-1500 Php (air-conditioned bus)	700Php
Station/Terminal Facilities	Restrooms, Security adequacy varies from one terminal to another	Station Office, Ticket Booth, Waiting Area, Parking Area, water, electricity, restroom, amenities for passenger loading ramp varies from one station to another

In terms of travel time, PNR has to improve its travel time to be at par with the travel time of the bus service. Furthermore, the frequency of travel of bus service is incomparable to PNR service of once a day, making PNR service inferior when it comes to schedule frequency. The average fare of bus and PNR service are near each which suggests competition in terms of cost. In addition to this, there are more beneficial features in PNR stations, which can also be improved. To further evaluate the performance of Bicol Express, we can compare its service to other rail operators in countries such as Malaysia, Thailand and Indonesia. As seen in Table 2, the average speed of Bicol Express needs to be improved compared to an existing rail service from Bangkok to Chiang Mai which is actually more than twice as fast as the rail service to Bicol. Table 2 summarizes the rail services available in South East Asia.

Table 2. Rail Service in South East Asia

OD	Travel Time	OD Distance (km)	Estimated Speed (kph)
Kuala Lumpur - Penang:	6 hrs, 10 min	293.63	47.62
Manila – Legazpi	13 hrs, 15 min	377.57	28.50
Bangkok - Chiang Mai	12 hrs	751.00	62.00
Saigon – Danang	16 hrs, 40 min	614.28	36.00
Jakarta –Surabaya	9 hrs, 40 min	522.00	53.98

The questionnaire survey developed was divided into four sections – the passenger's personal information, the basic travel information, the route specific travel information, and finally the SP component of the survey. Passengers' personal information includes gender, age, gross monthly income and civil status. Basic travel information includes the details regarding the purpose and the frequency of travel. The route specific travel information

includes the details of the trip itself, asking the travel time, and estimated cost, of the passengers' revealed preference (bus service). Lastly, the SP part of the survey involves the inclusion of a hypothetical rail system going to Bicol with improved services. In this portion of the survey, the respondents are presented different scenarios for train 1 and train 2, train one representing the old rail service and train 2 representing the improved rail service. The respondents were asked to choose between train 1, train 2, and their current mode choice. The attributes of train 1 and train 2 have different ranges as indicated in Table 3. The range of values for each attribute were designed considering the comparison of bus and train modes as well as the comparison of PNR with rail service in other parts of Asia.

The design of the survey forms had the following assumptions: Non air-conditioned and air conditioned buses have equal travel time. Train 1 has longer travel time but cheaper compared to train 2. Access and egress times are the same for the air-conditioned and non-air conditioned buses. Access and egress times for modes train 1 and train 2 are also the same. Surveys include personal information, route specific travel information and the stated preference survey that include 27 scenarios, each having a distinct set of values for travel time, access time, and fare.

Survey forms were pretested to 60 respondents, 20 for each batch in order to evaluate the performance of the survey forms in getting the necessary data for the analysis. The survey form was modified based on the results of the pretested survey data which include the socio demographic characteristics of the respondents as well as their mode choice characteristics which is composed of their revealed and stated preferences. The modified survey form was then used and the total number of valid respondents reached 900 samples.

The 27 profiles were grouped into three blocks, each block having 300 samples. Each respondent answered one from a single block and were asked about their preferred mode among alternatives. These samples were distributed to four different bus terminals in Metro Manila. These are the Cubao, Pasay, Alabang and Sampaloc terminals of buses going to Bicol. Other respondents from other bus terminals also participated in the survey but these were categorized as minor terminals. After the data gathering, the surveys were evaluated for validity. Inconsistent answers and incomplete information were rejected and replaced with new samples. After verification, the survey data was categorized based on gross monthly income, gender, age, and bus terminal location. Finally, analysis was done by identifying the significant factors affecting mode choice, using the NLOGIT software.

THEORY

To choose the main attributes of the bus and PNR Bicol express modes that are were to be part of the survey, significant factors identified from other similar studies were considered. Tischer & Dobson (1979) did a study on the shifting of passengers to buses and carpools for the purpose of recommending policies. In their study, it was found that convenience is the most significant factor affecting the mode choice of passengers. Convenience can be measured through the access time which is the time from the address of origin to the bus terminal. In a similar study by Alvinsyah & Nainggolan (2005), travel time and cost were considered significant and were used for the generation of the utility expression that will determine the probability of choosing a mode. More importantly, in a passenger survey conducted by CPCS (2013), a Canadian company, it was found that passengers choose bus for travel time, fare, comfort and convenience as the leading factors affecting their mode choice.

From Ben-Akiva and Lerman (1985) regarding the form of the multinomial Logit model, the probability of choosing a travel mode is given by eq. 1.

(eq.1) $$P_i = \frac{e^{V_i}}{\sum_{j=1}^{J} e^{V_j}}$$

where:
P_i *is the probability of choosing mode i*
V_i *is the utility of the mode i*
V_i *is the utility of mode j*

Table 3 Factors and their Attribute Levels for Trains 1 and 2

Levels		
	Train 1	Train 2
Travel Time(hrs)	7	4
	9	6
	11	8
Travel Cost	800	1200
	600	1000
	400	800
Access Time	15	15
	30	30
	45	45

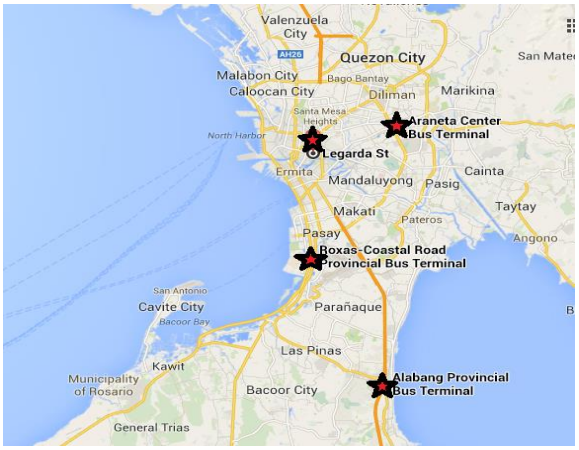

Figure 1. Location of bus terminals surveyed

RESULTS

4.1 Characteristics of respondents

The location of the bus terminals where the respondents were interviewed is shown in Figure 1. In this figure, it can be seen that majority of the respondents were interviewed in Cubao terminal, covering 39 percent of the whole 900 samples. The rest of the samples are divided to Alabang Terminal (13%), Pasay Terminal (30%) and Sampaloc (Legarda) Terminal (18%).

In Figure 2, it can be seen that the majority of the sample travel by bus to go home to Bicol or spend a vacation there, 66% of the respondents were female and 34% were male, 53% were married and 47% of the samples were single. However, gender and civil status were found to have an insignificant effect to the mode choice of the interviewed bus passengers. Figure 3 shows the gross monthly income of respondents. The samples can also be characterized based on the modes they have used when traveling from Manila to their Bicol destinations.

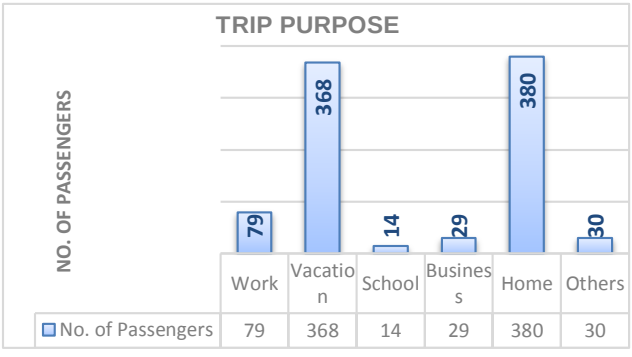

Figure 2. Trip purpose of bus passengers

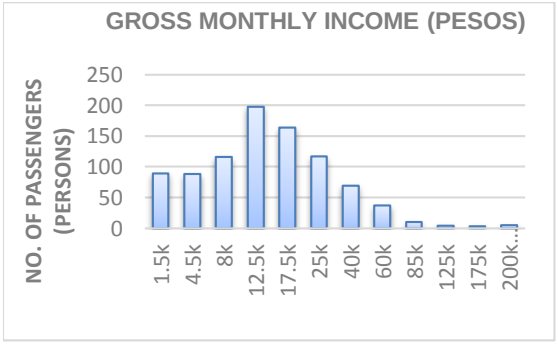

Figure 3. Gross monthly income of bus passengers

4.2 Travel time and fare study in Naga City

Results show that 607 of the 900 respondents disembarked in Naga City while the rest of the respondents disembarked in other parts of the Bicol Region. The most frequently used egress modes in Naga City are jeepneys and tricycles. Other modes include boat, bus, taxi, private car, SUV, van, motorcycle and walking. (Fig. 4)

To verify the answers of the respondents using these modes, a travel-time and fare study was conducted for jeepneys and tricycles. In this study, the following data were obtained: the route from Naga City Terminal to the final destination of bus passengers, the egress time, and the egress cost. Also, the locations of the final destinations of passengers disembarking in Naga City were noted.

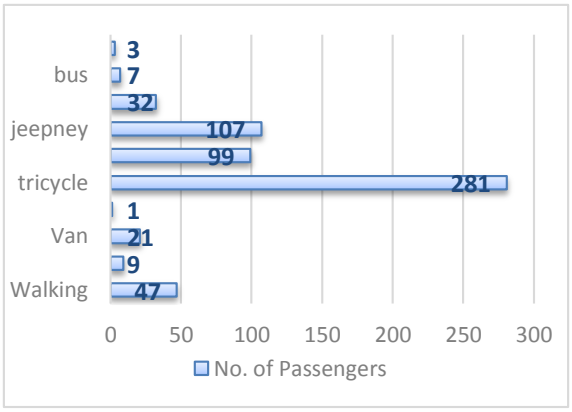

Figure 4. Egress modes of passengers

The travel time and fare from the Naga Terminal to the destinations of the jeepneys and tricycles were plotted to show the relationship of travel time and cost. (Fig. 5 and Fig. 6, respectively). The R-squared value of travel time versus travel cost for jeepney is 0.6207, while the R-squared vale of travel time vs. travel cost for tricycles is 0.1437 showing that the relationship of the said parameters are more linear for jeepney. This is because majority of the tricycle routes to the destinations above are considered "special" destinations that require higher fare than is charged than the regular destinations for tricycles.

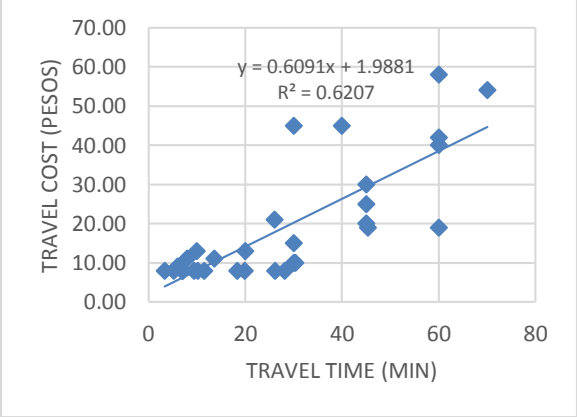

Figure 5 Travel time vs cost for jeepneys

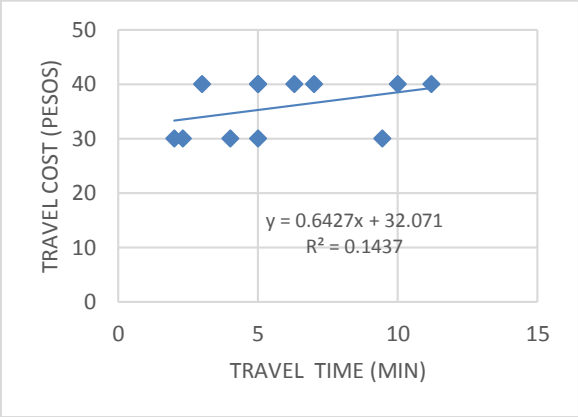

Figure 6 Travel time vs cost for tricycles

4.3 Logit model results

The answers of passengers for each scenario was tallied for air conditioned bus, non-air conditioned bus, train 1 and train 2. In all scenarios, the train is preferred over the current mode choice (air-conditioned bus service). Train 2 is preferred in 20 of the 27 scenarios while train 1 is preferred in 7 of the 27 scenarios. As for the NLOGIT results, Table 4 shows the NLOGIT result which include the tested variables and their respective coefficients and P-values. The variables include 'T_ORTR' - the time from the address of origin to the

terminal/station, 'INVEHT' - the main mode (bus or PNR) travel time, 'COST_INC' - the ratio of fare over the gross monthly income of the respondent, 'A_AIRCON' - the air conditioned bus mode constant, 'A_NONAIR' - the non air conditioned bus mode constant, 'A_TRAIN1' - the train mode constant representing PNR Bicol Express, and finally 'PNR1' 'PNR2' and 'PNR3' - the experience of Bicol Express train. Note that Train 2 being the base mode (0 constant value). Negative coefficients indicate disutility while p-values less than or equal to 0.05 are considered significant.

The model developed in this study involves the main effects as well as a dummy variable representing the experience of using the PNR system to travel from Metro Manila to the Bicol Region. In the survey forms, respondents were asked whether or not they have tried using the Bicol Express to travel to Bicol. Samples who answered yes were assigned a dummy variable one. Otherwise, the assigned value is zero. Please refer to Table 4 for the model results.

Based on the p-value of variables AIRXPNR1, NONXPNR2, and TRAXPNR3, the experience of riding the PNR Bicol Express has significant effect on the mode choice of bus passengers travelling from Manila to Bicol. The experience of riding the Bicol Express was found to be a disutility compared to the air conditioned bus and non-air conditioned bus indicated by the negative coefficient of AIRxPNR1 and NONXPNR2. However, the use of Bicol Express showed a utility for PNR represented by train1 and train2 which have a positive coefficient as indicated by TRAxPNR3 and the base mode. Access time from the address of origin to the station or terminal, the main mode travel time, and the main mode travel cost over income are also significant factors affecting the mode choice of passengers and are disutility to the mode choices. Furthermore, among the significant factors indicated in the NLOGIT results, the main mode cost over income is the factor which has the highest disutility, having the largest coefficient among all significant factors.

Table 4 LOGIT Model Results

Variable	Coefficient	P-value
T_ORTR	-0.00747	0.00000
INVEHT	-0.13294	0.00000
COST_INC	-1.09176	0.00000
AIRXPNR1	-0.41290	0.00000
A_AIRCON	-1.11354	0.00000
NONXPNR2	-0.69529	0.00023
A_NONAIR	-3.04819	0.00000
TRAXPNR3	0.13701	0.00080
A_TRAIN1	-0.21128	0.00000
Statistical Significance		
Log Likelihood Function	-7833.889	
Log Likelihood zero coefficient	-11227.598	
ρ^2	0.30226	
$\bar{\rho}^2$	0.30201	

Moving on, the elasticity and marginal effects of the significant variables were obtained. The model shows that a percentage change in access time of a particular mode in the choice set shows effects that are relatively inelastic for both direct and cross elasticity. This suggests that the probability of choosing any of the alternative is not sensitive to any changes in

access time. This suggests that though intermodality in the areas origin is implemented to improve the access time of passengers, it will only create little effect on the modal share. Hence, though access time was found significant, this may not be an urgent attribute to improve.

As for travel time, the model shows that a percentage increase in travel time of air conditioned bus results to a relatively elastic effect on the probability of choosing that alternative while all cross elasticity for this particular change show relatively inelastic effects. Results suggest that with an increase in travel time, the probability of choosing air-conditioned bus would decrease. This implies that there is a potential shift to another alternative when traffic along the bus route gets worse and causes the delay of its arrival. Moving on, a percentage increase in travel time of non-air conditioned bus show relatively inelastic effects for both direct and cross elasticity. In addition to this, an elastic effect on the probability of choosing non air-conditioned bus is only observed when the variable COST_INC is changed. This suggests that non air-conditioned bus passengers are already biased on their mode choice and may have been encouraged to use their current mode choice due to the variable COST_INC which represents the capacity to pay of the respondents.

For train 1 and train 2, a percentage increase of travel time results to a relatively elastic effect on the probability of choosing that alternative as well as the probability of choosing the other train mode (train 1 or train 2). Finally, it can be observed that the effect of a percentage increase in cost/income shows greater effect than that of the increase in access time and travel time. This verifies the result presented in the fourth SP model, which shows the largest coefficient for variable COST_INC. For a percentage increase in cost/income for a certain mode among the choice set, the direct elasticity are relatively elastic. In addition to this, a percentage increase in cost/income for air conditioned bus, train1 or train2 also shows a relatively elastic effect for all cross elasticities except for the mode non air conditioned bus.

CONCLUSIONS

Based on the results of this study, the following conclusions can be made:

1. To shift from bus to rail service, PNR should increase its level of service considering the significant factors affecting the choice of the bus passengers.

2. The modal shift from bus to rail system can be determined using a stated preference survey such as the one used in this study.

3. There is a positive consideration of ridership in favor of PNR based on the descriptive tally of stated preference. It is predicted that 87.97% of bus passengers would choose the rail service over their current mode choice where 36.16% would choose train 1 and 52.81% would choose train 2. However, the model's accuracy is only 43.66% which suggests that the model still needs to be improved.

4. Access time, travel time, and travel cost over income are significant factors affecting the mode choice of Manila to Bicol bus passengers and are disutility to the modes.

5. The survey samples gave importance to the respondents' capacity to pay for their mode choice as indicated by the highest coefficient and elasticity of the variable COST_INC.

6. Non-air conditioned bus passengers are most likely to choose their current mode choice since direct and cross elasticity for the change in attributes, show inelastic effect to the probability of choosing non-air conditioned bus as a choice.

7. The interaction effect of travel time and access time is significant such that the travelers would choose a mode even with a longer access time as long as the in-vehicle time is faster. The product of these two variables (i.e. interaction effect) is a disutility to the mode alternatives.

REFERENCES

Alvinsyah, Soehodho S and Nainggolan P J. (2005) Public Transport User Attitude Based on Choice Model Parameter Characteristics (Case Study: Jakarta Bus Way System). Journal of the Eastern Asia Society for Transportation Studies, pgs. 480–491.

Ben-Akiva, M. and Lerman, S. (2005), Discrete Choice Analysis: Theory and Applications to Travel Demand, The MIT Press, Chapter 3.

Caulfield, B. (n.d.). Discrete Choice Modeling [pdf file], retrieved from http://www.tcd.ie/civileng/Staff/Brian.Caulfield/T2%20%20Transport%20Modelling/Discrete%20Choice%20Modelling.pdf

Canadian Pacific Consulting Services (CPCS), (2013) Integrated Luzon Railway Project, prepared for PPP Center of the Philippines and DOTC

Hensher, D., Rose, J, and Greene, W. (2005) Applied Choice Analysis A Primer, Cambridge University Press, pg.412

Tischer, M.L. and Dobson, R. (1979) An empirical analysis of behavioral intentions of single-occupant auto drivers to shift to high occupancy vehicles. Transportation Research A, pg. 13