ANALYZING TRANSFER DISUTILITIES IN DISAGGREGATE MODE CHOICE MODELS FOR WORK TRIPS USING REVEALED AND STATED PREFERENCE DATA

Marites TUAZON
Supvg. Transport Dev't. Officer
Dept. of Transport & Comm.
Ortigas Ave., City of Pasig
Philippines
Fax:(632) 631-62-39

Olegario VILLORIA, Jr.
Associate Professor
School of Urban & Regional Planning
University of the Philippines, Q.C.
Philippines
Fax:(632) 97-56-64

abstract: This paper contains the highlights of the research which investigated the effect of the inclusion of possible measures of transfer inconvenience on disaggregate mode choice models for work trips. This was operationalized through the consideration of the different aspects of transfer such as walking, waiting, security risks, exposure to the elements and the use of stairs, with the latter forming an integral part of the rail based option. Models with and without the transfer variables were then estimated using combined revealed and stated preference data. It was found that adopting the variables for the use of stairs, maximum tolerable walking and waiting times and a generalized attribute for transfer inconvenience improved the specification and added significantly to the explanatory power of the mode choice models.

1. INTRODUCTION

Together with the other more common variables as travel time and cost, transfer disutility is a transport system attribute which, when properly operationalized, can be manipulated to serve as another explanatory variable in describing mode choice. Its effect on the explanatory power of mode choice models can be significant in the Philippine urban setting, where local conditions are not conducive for transferring due to inadequate if not non-existent transport facilities.

The impact can be more pronounced in the case of work trip makers who have significantly different travel behaviour compared to the other public transport users due to their higher valuation of time and distinct perception of inconvenience and personal security. These arise from the need to arrive at the workplace in the shortest time possible, with the least perceived effort expended and feelings of maximum safety. Such need, when not sufficiently met can directly affect work productivity, varying with the individual's socio-economic characteristics.

2. HYPOTHESES

The following hypotheses were tested:

1. Mode choice behaviour of work trip makers is influenced by the following factors :
    - Socio-economic characteristics of the trip maker such as personal income, age, gender, number of household members, combined household income and employment sector. Other individual characteristics that may affect decision making are maximum tolerable walking and waiting times under different transfer conditions.
    - Total cost
    - Travel time
    - Number and perceived quality of transfers
2. The mode choice model for work trips incorporating transfer disutility is a more effective tool in the analysis of travel demand than existing models.

3. The inconvenience of transferring is a significant determinant of mode choice behaviour.
4. The concept of transfer disutility can be operationalized in terms of the following variables :
    - incremental time for walking to get to the next mode
    - incremental time for waiting for the next mode
    - incremental costs of fare
    - incremental number of transfers
    - increase in the perceived level of inconvenience due to:
        - o Transfer movement :
            - horizontal or lateral by walking
            - vertical by climbing stairs
        - o Waiting discomfort :
            - standing
            - sitting
        - o Exposure to elements :
            - use of covered walks
            - use of waiting sheds
        - o Risks to security

3. MODELLING APPROACH

The disaggregate approach was adopted. Using this approach, the models that were calibrated take into consideration each individual trip maker's behaviour and choices as related to his socio-economic characteristics as opposed to using the aggregate approach wherein the estimated models are based on area-wide generalizations.

3.1 Model Specification

Basically two mode choices were considered. The Light Rail Transit (LRT) which is an elevated railway system along the alignment of Rizal and Taft Avenues accessed through the use of stairs and the jeepney mode which ply at road level beneath the line. A binary logit model assumed linear in parameters was specified. The variables that were considered are :

- dependent or response variable :
    - 1 if LRT was chosen
    - 0 if not
- independent variables :
    - socio-economic characteristics of the individual :
        - personal income
        - age
        - gender
        - employment group
        - combined household income
        - household members
    - system attributes :
        - travel time
        - total cost of travel
        - number of transfers
        - perceived level of transfer inconvenience

The latter variable was expressed in terms of a generalized attribute for transfer inconvenience, as will be discussed in the later section.

3.2 Model Calibration Technique

The data that is used in modelling transport behaviour is normally composed of the socio-economic characteristics of the individual as well as the details of the trips actually made. This type of data based on actual behaviour is called Revealed Preference (RP). However, the use of this limits the modeller to the number of survey respondents as the number of observations, necessitating a large sample size in order to arrive at a significant model.. Furthermore, the variables included in the model estimation may appear insignificant when there are not enough variations in the existing transport system attributes, which can very well be true for this case. In particular, there are not enough differences in the existing transport facilities being used by the respondents, save for the stairs which is specific to the LRT. It is also possible that total travel time, costs and number of transfers may not be significantly different from one individual to another.

Thus, another type of data set, called Stated Preference (SP) data, was utilized as supplement to the RP data. This was derived from survey experiments conducted together with the collection of the RP data and consists of presentation of hypothetical scenarios to the respondents. The SP and RP data were then pooled together in the final model estimation using the sequential estimation method presented by Ben-Akiva and Morikawa (1990).

4. SURVEY METHODOLOGY

A combined Revealed Preference (RP) and Stated Preference (SP) survey was conducted. The personal data and the RP portions of the survey were straight forward since these involved asking the respondents actual information. However, the formulation of the SP part required more preparation. The major source material in the determination of survey approach to be adopted is Jones' (1989) Lecture Notes on Stated Preference. The details of the various points that were considered in designing the SP survey are as follows :

- o Method of Interviewing - For the purpose of this study, face-to face interviews were conducted. This is due to the fact that the questions in the SP portion had to be discussed thoroughly with the respondents. This proved to be effective in ensuring a high response rate although the survey turned out to be more costly due to the higher compensation needed for the skilled interviewers.
- o Sample Selection - It was noted that SP sampling is less constraining than RP sampling, since it is not necessary that the respondent currently makes the kind of tradeoffs that were presented in the SP options. However, to maximise the realism of the exercise, respondents had to at least feel that the situation could apply to them. This is basically the reason that the sampling of the households interviewed was made random along the existing Light Rail Transit (LRT) corridor.
- o Form and Complexity of the Experiment - From among the different approaches discussed, a modified choice experiment was adopted for the second part of the SP portion. With this approach, considering all possible combinations of attributes and levels would considerably raise the number of questions per respondent. Thus, a simplification was necessary, i.e., the options were limited to three attributes namely total cost, total travel time and number of transfers with two levels for each attribute. In order to ensure that quality in the responses is maintained, it was further desired that an interview with a single respondent should last to a maximum of 25 minutes.

4.1 Scope of the Survey

Data for the Research was gathered from a sample of Metro Manila commuters who have experienced riding the LRT. Only work trips were covered and the trip information elicited were for a typical day of the week and for a typical time of the day the trip was made.

The combined RP-SP household interview survey was designed to capture work trip makers who have experienced using the LRT and who have this mode in their choice set. There are basically four types of these trip makers which are of interest, those who have to do at least one transfer in order to gain access to the LRT, those who have to make a transfer from the LRT to another mode in order to get to the destination, those who need to do both, and those who can use the LRT in going to work without making transfers. It was not aimed to capture those who need to do transfers before and after riding the LRT to get to work, instead, focus was given to the trip makers who belong to the first, second and third types. In order to do this, the survey was carried out in two segments. One was made on a random sampling of the households while the other was conducted in the workplaces. Both houses and work places were identified along the general vicinity of the Light Rail Transit Line (LRT) corridor which has a total length of 14.5 meters. The influence area was about 250 meters each side of the line which is assumed to be a convenient walking distance. About 100 households were sampled within this range while work establishments were predesignated and were earlier inquired upon on the availability of the employees for interviews during working hours.. Households directly along jeepney routes and those very far from the LRT station were also avoided, as it is assumed that members from these households are captive to jeepney transport to a certain degree. The survey were conducted by hired interviewers who have at least least two years of college education. A preliminary interview survey of about 30 individuals was also made prior to the final survey design.

4.2 The Respondents

The respondents had to meet the following criteria :

- o They must be regular work trip makers
- o They must regularly use public transport in going to work
- o They must have tried using the LRT at least once in going to work
- o They must have alternative modes or routes in going to work, with different levels of difficulties of transfers, i.e., either the number of transfers are different or are equal but one involves the use of stairs.
- o For interviews at workplace, the respondents must have access to the LRT station through the use of public transport only, i.e., the use of the LRT should involve at least one transfer.

4.3 The Interview Guide

For the household data, the total number of members, the combined household income per month, number of cars available for use and the number of working adults were inquired. During the household interviews, an adult working member for each household was asked his age, occupation, income and ownership of driver's license. For the workplace interviews, such information were asked from employees randomly selected within the designated workplaces. For the RP portion, the trip information gathered was for a typical weekday trip and included the mode information, origin and destination, trip purpose, total travel time, fares paid and the transfer details such as location, waiting time and types of

facilities availed of. The same set of questions was used for getting the details of the alternative mode or route considered as next best.

The first SP portion was meant to gather information on the respondents' perceptions and feelings regarding the basic aspects (subattributes) of transfers. Unlike the others however, the second SP portion of the interview is much more complicated. A hypothetical mode is to be compared with the current mode that the respondent is taking. There were different sets of questions for commuters who use stairs in transferring and for those who do not. The questions were asked for the exact circumstance that the respondent will transfer to another mode. To illustrate, a respondent may make two transfers in his current mode, costing P3.00 fare with a total travel time of 1 hour. The flow of questions will then start on a decreasing level of difficulty, as follows:

- With the same number of transfers and total travel time reduced by 25% (15 minutes), how much will he be willing to add to his present fare?
- With this shorter travel time but with the number of transfers reduced by 1, how much will he be willing to add to his present fare?
- With this less number of transfers and with cost reduced by 25% (P 0.75), what addition to travel time will he tolerate?

If the respondent currently undertakes a transfer involving stairs, the level of difficulty will be reduced up to a point where 1 transfer using stairs will be deducted. Then, going into the direction of increasing difficulty, the questions thrown would be basically the same but with changes having the opposite signs, e.g., the 25% reduction will be 25% addition and 1 transfer deduction will be 1 transfer addition. The highest level of difficulty will be for an additional transfer involving the use of stairs.

5. DATA PROFILE

Out of the 156 samples gathered, 126 were input to the computer for processing and analysis. The rest were rejected outright as spoiled returns, either due to missing vital information in the Revealed Preference (RP) part or to highly inconsistent answers in the Stated Preference experiment.

For the RP data, the number of observations used range from 89 to 104. For the SP data, this ranges from 693 to 729. Since there were about 8 hypothetical scenarios presented to each respondent, a complete set of additional observations from the SP experiment should be 1008. Thus, the actual rate of useable SP responses ranges from 68.75 percent to 72.32 percent. Combining the two data sets yielded useable observations ranging from 632 to 833 only.

5.1 Socio-Economic Profile

Among the respondents, there is a 40-60 percent split for male and female respectively. Since the respondents were limited to workers alone, only 4% are below 20 years of age, while 52% are between 20 to 30 years old. About 28 percent are between 30 to 40 years old and 10.4 percent are between 40 to 50. There is also a negligible share of respondents above 50 years old.

Employment is dominated by those working in private offices with 72.8 percent. Those working for the government is about 23.3 percent while 4% belong to other categories such as owned or home based business. Regarding personal income, about 20 percent have less than P 3,000 per month while 57% have between P 3,001 and P 5,000 per month. About 25% falls between the P5,001 to P10,000 bracket and a negligible number have higher than this.

Almost the same trend can be noted for the combined household income. About 20% are below P 5,000 a month, 25% are above P10,000 a month and 58% is represented under one bracket which is between P5,001 and P 10,000 per month. The rest have higher household income.

The mode for household size is 4 with a a flat distribution up to 21 members, which is explained by the traditional extended families. The average is about 5 members per household. Despite the fairly large household sizes, the mode for the number of working adults in a household is only 2, which is also the average.

5.2 Trip Data

The summaries of the trip details for both current and alternative (next best) modes are given in Tables 1 and 2. The standard deviations, minima, maxima and means for the different variables largely do not differ for both options, indicating that there may not be enough variations in the transport system attributes. Noteworthy, however, are the slightly lower averages for out of vehicle travel times (OVTT), total fare and number of transfers in the next best option. Even the components of OVTT such as total walking and waiting times as well as the total time spent for transferring are consistently lower. This is offset only by the higher in-vehicle travel time (IVTT). Congestion in the transport system can be inferred from the very high averages for IVTT in both cases, which are 40 minutes and 53 minutes for the current and next best modes respectively.

5.3 Perceptions Regarding Aspects of Transfer Inconvenience

Summaries of the responses yielded interesting findings on the interviewees perceptions on the inconvenience of transfers. First, the respondents were asked to rank the different factors which are hypothesized to make transferring from one mode to another inconvenient. Figure 1 shows that a substantial proportion ranked waiting, walking and use of stairs as the most important factors. On the other hand, many omitted security risk and exposure to elements signifying that these are the least important. (It must be further pointed out that none of the respondents specified other factors which were not presented to them). Converting the said rankings to scores, where the highest rank was given 5 points, the second 4 points, etc., waiting got the highest average score of 2.7, followed closely by walking and use of stairs with 2.2. as shown in Figure 2.

The respondents were then asked to rate the independent degrees of importance of the specified factors and the resulting frequency distributions are shown in Figure 3. Waiting consistently received the highest rating of importance, with more than 25 percent giving it a 10. About 15 percent gave walking and use of stairs the same rating. Exposure to elements however was given by more than 20 percent a rating of 9, which was not expected based on the earlier results. Security risk on the other hand remained to have a low rating of importance.

Further looking into the inconvenience of using the stairs, the respondents were asked if the stairs discourage them from using the elevated LRT and more than half responded 'No' as shown in Figure 4. Of those who answered yes, 67.7 percent would be more inclined to use the LRT if it was at ground level, 29.2 percent if an escalator is provided in lieu of the stairs. Any improvement will have no effect on the rest.

Regarding perceived risks to security, the respondents were asked on their knowledge of crime occurrences at the transfer locations for their current and next best modes. Interestingly, it can be noted from Figures 5 and 6 that more have indicated knowledge of crimes occurring at current transfer locations (62.9 %) than at the alternative ones (52.4 %). Moreover, the percentage of

Table 1 Summary of Trip Details, Current Mode

Variable	Mean	Std. Dev.	Minimum	Maximum
Total Transfer Time, min	9.38	9.32	0.00	59.00
Out of Vehicle Travel Time, min	23.00	14.41	0.00	98.00
Total Travel Time, min	62.40	29.10	10.00	170.00
In-Vehicle Travel Time, min	40.90	24.70	5.00	145.00
Number of Transfers	1.27	0.68	0.00	4.00
Total Fare, Pesos (P)	8.88	5.98	1.50	4.80
Total Walking Time, min	8.25	6.64	0.00	35.00
Total Waiting Time, min	14.77	9.54	0.00	66.00

Table 2 Summary of Trip Details, Next Best Mode

Variable	Mean	Std. Dev.	Minimum	Maximum
Total Transfer Time, min	8.77	8.61	0.00	46.00
Out of Vehicle Travel Time, min	21.62	15.05	0.00	100.00
Total Travel Time, min	71.88	33.48	15.00	195.00
In-Vehicle Travel Time, min	53.03	29.10	5.00	171.00
Number of Transfers	1.16	0.64	0.00	4.00
Total Fare, Pesos (P)	8.68	5.90	1.50	4.00
Total Walking Time, min	8.04	6.26	0.00	35.00
Total Waiting Time, min	13.60	11.05	0.00	70.00

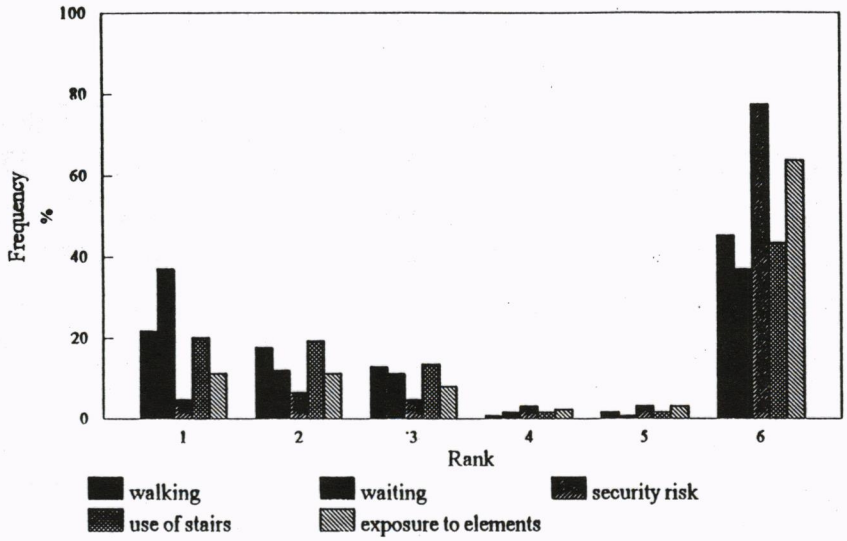


Figure 1 Ranking of Factors which Make Transfers Inconvenient

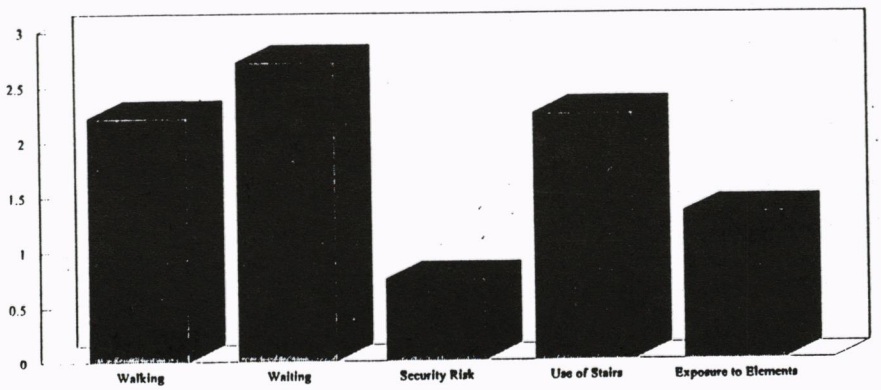
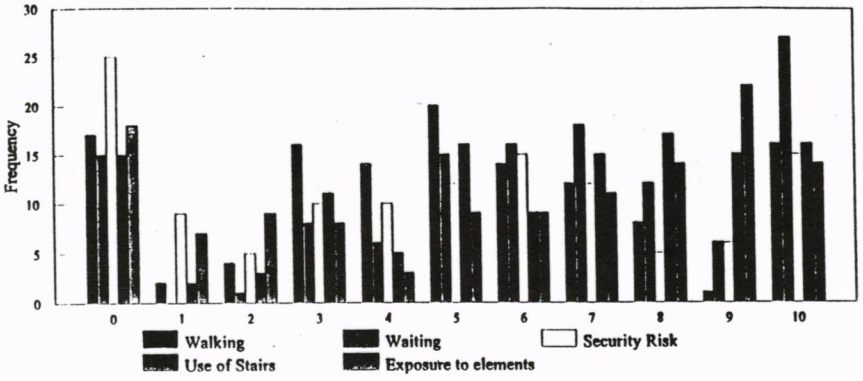


Figure 2 Scores for Factors which Make Transfers Inconvenient



Highest = 10

Figure 3 Degree of Importance of Transfer Aspects

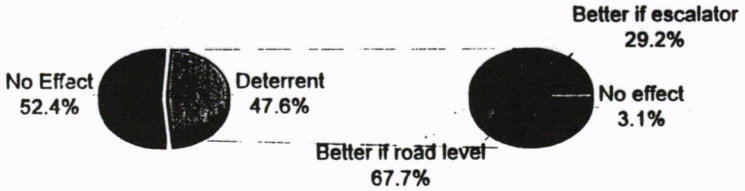


Figure 4 Effect of Stairs on Mode Choice

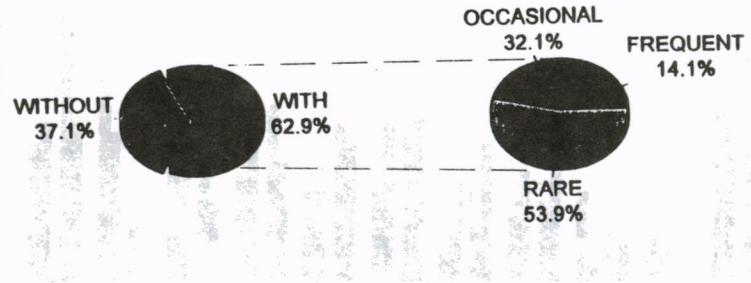


Figure 5 Knowledge of Crimes at Current Transfer Locations

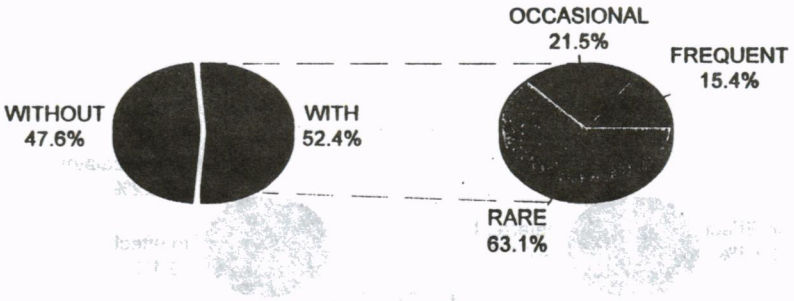


Figure 6 Knowledge of Crimes at Alternative Transfer Locations

rare occurrences is higher for the next best mode. These further confirm the low level of importance being given on security risks.

Perceptions regarding walking and waiting were analyzed using varying levels of convenience. Willingness to wait was operationalized into maximum waiting time tolerable under three different conditions : standing and without the benefit of shade, standing under a shade and sitting under a shade. All of the respondents will wait up to 5 minutes under any condition. More than 80 percent will wait under any condition for 10 minutes, 20 percent standing and unprotected from the rain or sun. Almost all of those willing to wait for 25 minutes should be sitting under a shade. The average of the maximum tolerable waiting times under the different conditions are as follows :

Standing and Without Shade	1.6 minutes
Standing and With Shade	2.1 minutes
Sitting and With Shade	3.0 minutes

Maximum time that walking is tolerable was then asked for paved and rough grounds, with and without shade for 5 minute intervals. The same pattern can be noted for walking on paved and rough grounds. All of the respondents will walk for 5 minutes under any condition. More will walk for 10 minutes on paved rather than rough ground and the larger portion of them should be under a shade. The highest tolerable walking time on rough ground is 30 minutes under a shade although one vigourous respondent can walk for 45 minutes on paved ground even without the benefit of a shade. The average tolerable walking times are :

On Paved ground, Without Shade	5.4 minutes
On Paved ground, With Shade	7.7 minutes
On Rough ground, Without Shade	4.9 minutes
On Rough ground, With Shade	7.1 minutes

5.4 Data Summary

The following points can be inferred from the data :

- Based on the means, there are not much differences in the system attributes for the current and next best modes.
- The three most important factors which make transfers inconvenient are waiting, walking and use of stairs. The least are exposure to the sun or rain and risks to security. It shoud be noted that the respondents did not specify factors other than these.
- Surprisingly, respondents have higher tolerable walking times than waiting times. This can be due to the very high frequencies of public transportation that can be actually availed of. This is also consistent with the degree of importance that is accorded to waiting as a factor in transfer inconvenience.
- There are only slight differences of half a minute each for the average waiting times under different conditions. The existence of waiting facilities such as shades and seats thus lose importance due to the very limited time the respondents are willing to wait.
- The average tolerable walking times also vary slightly for paved and rough grounds. As expected however, the average walking time under a shade is significantly higher than that for without.

6. METHODOLOGY FOR MODEL ESTIMATION

In order to confirm the advantage of using mixed estimation models, separate models without the transfer variables were calibrated using Revealed Preference (RP), Stated Preference (SP) and the combined data sets. From the best model, the transfer variables were added one by one, and the ρ^2 and LR tests described earlier were carried out each time as a way of determining the better model.

In all of the estimation tests, the following steps were carried out in eliminating unnecessary variables:

- Initially, all of the variables were forced into the model.
- Related variables were taken out based on their signficance levels.
- Each run, the least significant variable is eliminated until all of those left have a p-value of 0.10 or better, i.e., the null hypothesis that they are significantly different from zero can be rejected at the 90% confidence level.
- Variables with the wrong coefficient sign were further excluded.

For the model estimation, the system attributes of the jeepney option were subtracted from those for the LRT. On the other hand, the socio-economic (SE) variables take the value of zero for the road based option. The response variable Y is equal to 1 when the LRT is chosen and the models are estimated for its probability. A maximum of 50 iterations was specified for each run. The RP-SP data sets were pooled using Ben-Akiva and Morikawa's sequential estimation method (1990). The scale coefficient arrived at was 0.952.

The base model, i.e., without transfer variables, that was arrived at has age, employment group and total travel time as significant variables. Shown in Table 3 are the different transfer variables that were incorporated in the model estimation. Most noteworthy of these are the different estimates of the "generalized transfer inconvenience" variable, the derivations of which will be discussed in the succeeding section.

6.1 The Generalized Transfer Inconvenience Variable

The concept was based primarily on Spear's Generalized Attribute variable for mode choice models (1974,1976). For this research the variable was defined as :

$$A_{im} = \sum_{j=1} w_{ij} \times y_{ij} \qquad (1)$$

where :

A_{im}= value of the generalized attribute for individual i for mode m
w_{ij} = relative sensitivity of individual i to a particular subattribute j.
y_{ij} = individual's perceived satisfaction with travel mode m with respect to subattribute j

For this case, the generalized attribute calculated is that for the transfer variable with waiting, walking, use of stairs, risk to security and exposure to the elements as the subattributes. The relative sensitivity w_{ij} is taken as the respondents' ranking of each subattribute divided by the sum of the ranks given. The variable y_{ij} on the other hand is taken as of the "dissatisfaction" of the individual to the current mode. This was obtained as the level of importance accorded by the respondents to each subattribute as a factor which makes transfers inconvenient. The highest value that the inconvenience variable can take is

10, and it has an average of 7.6, with most of the values ranging from 5 to 10, reflecting the high consideration of the respondents for the various aspects of transfer inconvenience.

The first form of the generalized transfer attribute considered involves only walking and waiting as the subattributes. The level of significance of the null hypothesis is 0.0001 but the difference of the Log Likelihood from the restricted or base model jumped to a highly significant level. The ρ^2 on the other hand is 0.359. However, the level of significance of the Age variable was reduced while the Generalized Transfer variable itself is not significant. It has the correct negative sign, which is what is expected, considering that this attribute is an inconvenience index, i.e., the more the perceived inconvenience is, the less the utility of the base mode LRT.

Other versions of the generalized transfer variable were considered. One case involved the three most important subattributes of transfer: walking, waiting and use of stairs. The results are much improved from that of the previous model. The ρ^2 is higher at 0.532, while the parameter estimate for the Generalized Attribute, still with the proper sign, gained significance. The variable Age became less significant.

The next case takes into account all of the five subattributes. With the same p-value of 0.0001, the ρ^2 is even higher at 0.745. The Generalized Attribute variable still is very significant while Age further slid sufficiently enough to be eliminated from the model.

7. FINDINGS AND RECOMMENDATIONS

A summary of the results for the 'better' mixed models as well as the restricted model are shown in Table 4. The model designations are :

Model Number	Variables Included
1	Age, Employment Group, Total Travel Time (Base Model)
2	Model 1 + Use of Stairs
3	Model 1 - Age + Generalized Transfer Attribute for walking, waiting, use of stairs, risk to security and exposure to elements
4	Model 1 + Maximum Walking Time Tolerable under Shade
5	Model 1 + Maximum Walking Time Tolerable without Shade
6	Model 1 + Use of Stairs + Maximum Walking Time Tolerable without Shade

All of the estimated parameters have the expected signs and hardly vary among the models in which they are included. Furthermore, the levels of significance that these are equal to zero are very low and the p value for the models are all equal to 0.0001. All of the transfer variables introduced add to the explanatory power of the models. Basing from the ρ^2 and the percentage correct however, Model 3 with the Generalized Transfer Attribute has a much higher explanatory power.

To summarize, the following findings are the major highlights of this research :

- The socio-economic characteristics of the trip maker which significantly influence work trip mode choice are age and employment group. The latter is basically composed of two groups, those who are employed at private offices and those working either with the government or owned / home based business. The classification was based primarily on less strict requirement on work time arrival.

Table 3 Transfer Variables for the Model Estimation

Case	Variable Added to Restricted Model	Description
1	Number of Transfers	number of times transfers are made
2	Use of Stairs	number of times stairs are needed
3	Gen. Transfer 2	generalized transfer attribute for walking and waiting
4	Gen. Transfer 3	generalized transfer attribute for walking, waiting and use of stairs
5	Gen. Transfer 5	generalized transfer attribute for walking, waiting, use of stairs, risk to security and exposure to sun and rain
6	Adj. Use of Stairs	Use of Stairs x relative sensitivity of user x dissatisfaction index of user
7	Max. Waiting Time 1	maximum waiting time for a transfer that can be tolerated while standing under a shade
8	Max. Waiting Time 2	maximum waiting time for a transfer that can be tolerated while standing without shade
9	Max. Walking Time 1	maximum walking time for a transfer that can be tolerated under a shade
10	Max. Walking Time 2	maximum walking time for a transfer that can be tolerated without a shade
11	Max. Walking Time 2 and Use of Stairs	combination of Cases 2 and 10

Table 4 Summary of Mixed Estimation Models

Variable		Model 1	Model 2	Model 3
Intercept	Parameter Estimate	3.6120	6.1000	8.953
	p Value	0.0001	0.0001	0.0001
Age	Parameter Estimate	-0.0450	-0.0450	-
	p Value	0.0001	0.0001	
Employment Group	Parameter Estimate	-1.4180	-1.3830	-1.0413
	p Value	0.0001	0.0001	0.0001
Total Travel Time	Parameter Estimate	-0.0260	-0.0240	-0.0244
	p Value	0.0001	0.0001	0.0001
Use of Stairs	Parameter Estimate	-	-1.3540	-
	p Value		0.0001	
Generalized Transfer Attribute 5	Parameter Estimate	-	-	-0.06017
	p Value			0.0001
Maximum Walking Time Under Shade 1	Parameter Estimate	-	-	-
	p Value			
Maximum Walking Time Without Shade 2	Parameter Estimate	-	-	-
	p Value			
L (B)		-462.45	-446.68	-136.01
p value		0.0001	0.0001	0.0001
Rho-Square*		.0162	0.191	0.745
% Correct, Probability Level = 0.9		39.4	43.2	87.1
No. of Observations, N		833	833	805

Variable		Model 4	Model 5	Model 6
Intercept	Parameter Estimate	3.1770	3.3740	6.0610
	p Value	0.0001	0.0001	0.0001
Age	Parameter Estimate	-0.0430	-0.0410	-0.0410
	p Value	0.0001	0.0001	0.0001
Employment Group	Parameter Estimate	-1.4270	-1.9230	-1.8940
	p Value	0.0001	0.0001	0.0001
Total Travel Time	Parameter Estimate	-0.0260	-0.0270	-0.0260
	p Value	0.0001	0.0001	0.0001
Use of Stairs	Parameter Estimate	-	-	-1.4870
	p Value			0.0001
Generalized Transfer Attribute 5	Parameter Estimate	-	-	-
	p Value			
Maximum Walking Time Under Shade 1	Parameter Estimate	-0.0820	-	-
	p Value	0.0032		
Maximum Walking Time Without Shade 2	Parameter Estimate	-	0.0134	0.1160
	p Value		0.0001	0.0001
L (B)		-355.51	-408.67	-393.31
p value		0.0001	0.0001	0.0001
Rho-Square*		0.1660	0.2210	0.2500
% Correct, Probability Level = 0.9		41.5	44.8	49.1
No. of Observations, N		632	797	797

*using the alternative definition 1-(L(B)/L(c))

- Of the directly quantifiable system attributes, only travel time appears to affect mode choice. Of its components, in-vehicle travel time and total waiting time have the significant influence. Total cost proved to be an insignificant variable, while the influence of number of transfers alone could not be properly estimated due to insufficient variations.
- Factoring in the individual's maximum tolerable walking time under the conditions of with and without shade improved the explanatory power of the model.
- The number of times the stairs will need to be used also has a similar effect on the model. Combining this with the maximum tolerable walking time without shade further improves the model significantly.
- Transfer disutility can be best operationalized by expressing it in terms of a generalized inconvenience attribute. This is a function of the relative importance and the degrees of dissatisfaction of the individual on the different factors or subattributes, viz., waiting, walking, use of stairs, security risk and exposure to the sun and rain. Incorporating this into the model improves its explanatory power to a much higher level although it renders the variable age as insignificant. This may be due to the fact that age, being an indication of the level of effort expended, only comes into the model as a proxy variable for the level of perceived inconvenience.

It can be concluded that models for predicting mode choice behavior of Metro Manila public transport users with the purpose of going to work should include transfer inconvenience. This can be operationalized in various ways. Maximum tolerable walking times under different conditions and the number of times the stairs will need to be used are two variables which can be used in improving the predictive power of the models. However, the best expression of transfer disutility which can be incorporated in the model is the generalized transfer inconvenience attribute. This can be estimated from individuals' stated preference responses on the relative importance and degrees of dissatisfaction with the various transfer subattributes.

With the above findings, it was shown that the feelings and perceptions on the inconvenience of transferring from one mode to another cannot be disregarded. A major practical application of these results is in the area of forecasting mode riderships, for instance an LRT system which has the same design and operational characteristics as the existing line. Increase in patronage arising from the integration of branching or intersecting LRT lines and the provision of escalators in lieu of stairs can also be analyzed by utilizing models with the variable Use of Stairs.

However, in view of the rather limited goal of determining the effect of transfer inconvenience and not in calibrating a model which can be readily adopted in predicting mode split, several points for undertaking further research can be recommended. Needless to say, this research has demonstrated the advantages of using SP responses in model calibration. Thus, future data collection efforts for mode choice modelling should include SP inquiries which will explore the users' perceptions on transfer inconvenience and this can be expanded to include comfort.

Additional improvements to the exercise can also be made, one of which is in the analysis of the cost attribute. It can be pointed out that cost as a variable was eliminated from the model building due to lack of significance. This may be due to the insufficient variations in its values both for the actual and hypothetical scenarios covered in the surveys. Thus, new researches employing SP experiments should present hypothetical scenarios involving larger variations in cost.

Finally, it will also be of interest if model estimations for the other trip purposes will yield similar results, in view of the encouraging results obtained for the work trip models. In the end, it is hoped that a new and better class of mode choice models for all trip purposes in Metro Manila, incorporating not only directly measurable attributes but also subjective ones, will be arrived at.

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