PUBLIC TRANSPORT TICKET USAGE SURVEYS – A METHODOLOGICAL DESIGN

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Abstract:

This paper describes a survey technique which has been used for the measurement of public transport ticket usage rates. The objective of the survey was to provide information to assist in the allocation of fare-box revenue to operators within a privatised public transport framework. The method has been shown to work successfully and to provide credible estimates of ticket usage.

A principle methodological aspect of the survey was the need to recognise, in advance, that the sampling method was not truly representative, and that extensive weighting would need to take place in order to obtain unbiased population estimates. In order to do this, specific information needed to be recorded before and during the survey, rather than waiting for the analysis phase before realising the need for weighting data. Similarly, the use of multiple survey methods (ticket usage questionnaire and observational survey) was necessary in order to obtain an estimate of the effects of non-response bias.

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BACKGROUND

The Government of Victoria is currently in the process of privatising Victoria's public transport system as an integral stage in the reform of the transport system. As part of this process, Melbourne's train system will be run by two operating companies (Hillside Trains and Bayside Trains), the tram system will be run by two operating companies (Swanston Trams and Yarra Trams), the bus system will be run by a large number of private companies (as now happens), while V/Line Passenger will also be run by a private company. During and after this privatisation process, it is the intention of the Government to retain the existing multimodal MET ticketing system as the primary means of ticketing (although individual operators will also have the opportunity to introduce single-company tickets for those trips which do not need to take advantage of the multimodal benefits of the MET ticketing system). In such an arrangement, all revenue from the sale of MET tickets will go to a Clearing House, which will then distribute it to the operating companies according to a revenue allocation process (which is currently in the final stages of development by the Transport Reform Unit within the Department of Treasury and Finance) which recognises the passenger loads carried by each of the operators.

The Transport Research Centre was commissioned by the Transport Reform Unit to undertake the design and conduct of Customer Surveys on the Victorian public transport system to support the revenue allocation process. The Public Transport Revenue Allocation Survey (PUTRAS) is to be used to support the calculation of fare-box revenue allocations to each of the companies operating public transport services under the privatised system arrangements (Hillside Trains, Bayside Trains, Yarra Trams, Swanston Trams, Route Buses and V/Line Passenger). The revenue allocation process will use a procedure whereby passenger loadings (trips and distance covered) on each property will be estimated by first calculating usage factors for each of the major ticket types sold in Melbourne (i.e. by ticket type and by ticket zone) for each property. These usage factors will then be applied to the sales of the various types of tickets in each time period to estimate passenger loadings. These loadings will then be used in a Revenue Allocation Formula to calculate the distribution of the fare-box revenue to each of the operators.

SURVEY OBJECTIVES

The Public Transport Revenue Allocation Survey (PUTRAS) will be required to provide ongoing quarterly and annual estimates of the total number of trips on each property and the distance covered by these trips, such that quarterly and annual estimates of revenue share can be calculated for each property, according to a government-specified Revenue Allocation Formula. The survey should also be able to identify tickets which are used on the Survey Day only on one property (e.g. Yarra Trams), or on one mode (e.g. only on trains). It is also desirable that the chosen survey method be able to provide other information about public

transport usage (such as trip origins and destinations, basic passenger demographics and route catchment areas) which would be useful to the tenderers for the privatised services, and to the eventual operators of the services. The sample size for PUTRAS must be such that the annual revenue share for each property is accurate to within 2% of the mean for that property at the 90% confidence level.

METHODOLOGICAL OPTIONS

A number of options were available for the design of monitoring surveys for the revenue allocation process. For each option, the major objective was to measure the number of boardings and the total passenger kilometres travelled on each property. In designing a survey method, four basic questions had to be addressed:

1. What recording method would be used
   - field counts or ticket usage questionnaire surveys?
2. What level of survey technology would be used
   - manual or automatic counting systems?
3. Where would the surveys be performed
   - on board vehicles or at transit stops?
4. How would the sample survey results be expanded to population totals
   - direct estimation of results by internal scaling-up of the observations, or the application of trip rates to a secondary control variable such as ticket sales?

The relative advantages of the options for each question include:

Recording Method

Field Counts

Description:
Field counts cover the range of survey methods which involve simple observational measurements of passenger flows in the field. These flows may be counted or measured in various ways, but a common feature is that little or no interaction occurs between the observer and the subjects being observed.

Advantages:

- easy to explain and apparently objective measure of passenger flows
- relatively simple "technology" for the survey

Disadvantages:

- subject to bias if sample is not correctly selected
- difficulties in recording flows under peak loading conditions
- cannot obtain more detailed information about passengers

Ticket Usage Questionnaire

Description:
This estimation of boardings and passenger kilometres involves the use of a questionnaire to determine the manner in which each ticket is used by asking travellers how they have used their tickets on a specific day.
Advantages:

- a detailed history of ticket usage is obtained, including multimodal use of tickets (of various types) on different routes and properties
- demographic and trip purpose data can be asked of the traveller, thus enhancing the value of the data to the operators in terms of market information
- the individual boardings can be linked into multimodal trips for a single purpose
- the same method is applicable across all modes, thus enhancing comparability of the ticket usage rates

Disadvantages:

- the method requires interaction with passengers, although the level of respondent burden can be kept low with good survey design
- there is scope for non-response and non-reporting of trips, although this can be controlled through good survey administration and weighting procedures

Level of Technology

Manual Counts

Description:
Field observers manually count passenger flows using either pencil-and-paper recording methods or computer-assisted methods.
Advantages:

- the observers can record some limited types of other information, such as type of ticket used
- the observers can perform some validity checks on the data recorded, because they are actually observing the flows
- no substantial capital costs are involved in mounting the survey (unless a highly computer-assisted survey is used)

Disadvantages:

- a large field force of survey personnel is required
- the process is relatively costly to mount on a regular basis
- problems with observer reliability can become an issue in an ongoing survey

Automatic Counts

Description:
Passenger flows are recorded automatically using either treadle mats (for trams and buses) or barrier counts for train stations.

Advantages:

- the data can be recorded continuously at the instrumented sites
- the ongoing costs of the survey are relatively low

Disadvantages:

- a substantial capital cost is involved
- not all vehicles or stations can be instrumented
- equipment reliability can become a problem
- other characteristics of the passenger flows cannot be recorded
- because they are unattended, there is scope for spurious observations

Location of Surveys

On-board Surveys

Description:

Passenger flows are recorded by observers or counting devices located on the vehicle.

Advantages:

- this method is suitable for systems where there are few vehicles by comparison with the number of stops (e.g. trams and buses)
- the observations are performed in relatively close proximity to a driver
- other information can be recorded about the movement of the vehicle (e.g. running times)

Disadvantages:

- special care needs to be taken in the sampling of vehicles
- reliability problems can occur with on-board automatic counters

At-Stops Surveys

Description:

Passenger flows are recorded by observers or counting devices located at transit stops.

Advantages:

- this method is suitable for systems where there are few stops in comparison with the number of vehicles (e.g. trains)
- automatic counters, if used, are stationary, thus improving reliability

Disadvantages:

- limited time may be available for observers to record both boardings and alightings during the stopped time of the vehicle

Expansion Method

Direct Estimation

Description:
Direct estimation of boardings and passenger kilometres involves the simple expansion of the observed flows by the inverse of the sampling rate employed in the survey design. No reference is made to other sources of data to assist in this expansion.
Advantages:

- no secondary data is required for the estimation of population totals

Disadvantages:

- subject to greater sampling error because the survey is trying to estimate the seasonal fluctuations in flows; as a result, a larger sample size is required to obtain the desired precision

Estimation from System-Wide Ticket Sales

Description:
This estimation of boardings and passenger kilometres involves the application of ticket usage rates for trips made on a particular property to the sales of tickets in the entire system (for example, trips on Yarra Trams and passenger kilometres on Yarra Trams per ticket sold in the system).
Advantages:

- the ticket sales data (which is relatively accurate because of auditing requirements) accounts for the seasonal fluctuations in usage
- the ticket usage rate survey need only account for the relative usage of the tickets

Disadvantages:

- assumes that ticket sales data is available in a timely manner

Based on the above descriptions of advantages and disadvantages, the following methods were judged to be the major candidates for final selection:

1. direct estimation using field counts
2. direct estimation using ticket usage questionnaire
3. expansion from system-wide ticket sales using ticket usage questionnaire

Since the system-wide ticket sales were likely to be available as part of the revenue collection and allocation process, it seemed reasonable to estimate patronage from these figures, rather than attempt to estimate patronage directly without using the ticket sales data as a controlling variable, since the use of the ticket sales data would also lead to a reduction in required sample size and hence survey cost. Therefore, method 3 was preferred to methods 1 and 2. However, it was considered prudent to design the survey in such a way that alternative estimates of system usage could be obtained using methods 1 and 2 if required.

THE ADOPTED SURVEY TECHNIQUE

The PUTRAS survey was conducted (during the first quarter of 1998) by teams of two people riding the public transport vehicles. The main survey was conducted using a mail-back questionnaire which was handed to passengers soon after they boarded the vehicle and which they were asked to send back to the survey office at the end of the day. In addition, all passengers boarding the vehicle were counted, and the characteristics of passengers randomly selected for receiving a questionnaire were recorded.

The questions in the survey covered three main areas of interest:

- first, the questionnaire asked about the ticket being used on the current trip
- then we asked about the traveller themselves
- finally, we asked about all trips made on that day on the ticket being used at the time of receiving the survey.

In addition to the information received from passengers returning the survey form, an Interview Control Sheet was maintained one of the surveyors in the survey team. In addition to details about each run surveyed (e.g. starting time, route number etc), the Interview Control Sheet recorded the total number of boarding passengers, plus details of every passenger selected to receive a survey. These details included the age and sex of the person and the type of ticket they were using at the time (in terms of ticket type and ticket zone). The Interview Control Sheet also recorded any reasons why a selected passenger did not receive a questionnaire (e.g. refusal, got off vehicle too quickly etc).

In intercept surveys such as PUTRAS, it is important that passengers be selected randomly for distribution of the questionnaire. To ensure this, PUTRAS surveyors were instructed that they MUST give the questionnaire to every nth passenger boarding the vehicle on each trip. It did not matter whether this nth person was young, old, male or female, they should be given the form for completion. The other surveyor (completing the Interview Control Sheet) identified which passenger should receive the questionnaire. Substitution sampling was not permitted. If the selected passenger refused to accept the survey form, the questionnaire was retained by the surveyors unused. The surveyor simply went back to the other surveyor to find out who the next nth passenger was, or waited until the next nth passenger boarded the vehicle, and then gave the next sequentially-numbered questionnaire to them.

The ticket usage questionnaire sought information on three topics; the ticket being used, the traveller and the trips made on the ticket. Ticket information included ticket type and ticket zone, fare type (full-fare or concession), ticket price, and when and where ticket was bought. Travellers were asked their gender and year of birth, whether they were a visitor to Melbourne, their suburb of residence (if a resident), their employment status, and whether they were a tertiary student.

The "trip diary" portion of the questionnaire sought details of all trips made on the specified ticket on the Survey Day. Respondents were asked to provide the time of starting the public transport trip, the mode used, the bus or tram route number, and the starting and finishing points of each trip. For train trips, this would be the starting and finishing stations. For bus and tram trips, information was sought on the intersection nearest the starting and finishing bus or tram stop.

PILOT TESTING

A full pilot survey of the proposed PUTRAS methodology was conducted in November 1997. The Pilot Survey covered two full days of surveys on each of the five proposed properties, spread over a week. As a result of the Pilot Survey, a number of changes in the survey methodology were incorporated in the main PUTRAS survey, including:

- Increasing the sampling rate on-board the vehicles
- Addition of 60+ tickets to the list of ticket types
- Providing specific location categories for where the ticket was bought
- Including am/pm time boxes in the trip starting time question
- Recording the actual end time of run on the Interviewer Control Sheet
- Recording the number of carriages available for use of trains
- Redesigning the trip diary to include specific sections for trips made before the survey was received, the trip being made when the survey was received, and trips made after it was received.

DESIGN OF THE SAMPLE

The survey covered all modes of public transport (trains, trams and buses) within the metropolitan area of Melbourne. In the initial three month survey period, which is the subject of this paper, surveys were conducted on every day from February 3 through May 3 1998 (with the exception of Grand Prix day and Good Friday). The sample size for PUTRAS was such that the annual revenue estimated for each property via the subsequent revenue allocation formula process had to be accurate to within 2% of the mean revenue for that property at the 90% confidence level.

The calculation of the sample size required to meet the levels of precision described above was undertaken using data collected in the Victorian Activity & Travel Survey (VATS) in 1994 and 1995. In the VATS survey, details were obtained for public transport trips made by residents of Melbourne on each day of the survey year. For each public transport trip (defined as a boarding of a public transport vehicle), details of the traveller and the ticket used were also obtained. An analysis was undertaken using this database of public transport trips which would replicate as closely as possible the data which might be obtained by the ticket usage survey being recommended for the PUTRAS project. Thus for each trip made,

the details of how the ticket being used on that trip was used on other occasions during the day were identified.

Using the VATS 94/95 Public Transport database, which contained 8346 trips made on 3669 tickets by 3277 different travellers, the mean number of trips made per day on each property by the type of zonal ticket used was calculated and, by utilising the techniques of sample replication, it was possible to calculate the standard errors of the estimates of the means. The same process was repeated to calculate the mean and standard error of the kilometres travelled and, using the proposed revenue allocation formula, the mean and standard error of the revenue earned by each property.

Because of the relatively small size of the VATS Public Transport database, all of the sampling errors in revenue allocation were far more than the allowable error of 2% specified for the PUTRAS survey. The only way that the errors could be reduced was by increasing the sample size of tickets from which the ticket usage rates are calculated. The VATS sample size was therefore scaled up in order to reduce the relative errors within each property to the allowable maximum of 2% per annum. On the basis of the VATS analysis and the revenue allocation formulas under consideration at that time, it was estimated that a total annual sample size of nearly 100,000 tickets would be required to obtain the required precision.

The sampling process adopted was a multi-stage process. Ideally, a random sample of tickets would be required for analysis. However, in practice, this was obtained via a multi-stage, stratified sampling process with unequal sampling rates, with appropriate weighting techniques in the data analysis phase (as will be described later). The multi-stage process consisted of four basic phases:

1. Select routes to be surveyed on each day
2. Select runs to be surveyed on each route on each day
3. Select carriages to be surveyed on each run
4. Select passengers to be surveyed on each carriage

CONDUCT OF THE SURVEY

The conduct of the survey, and the subsequent analysis, required the assembly of substantial databases describing the public transport system. Given the tight deadlines for commencing and completing the surveys (the contract was let in mid-December 1997, the surveys commenced on February 2, 1998, the Phase 1 surveys finished on May 3, 1998, and the analysis was completed by end of June 1998), it was fortunate that the Transport Research Centre had assembled most of these databases in GIS format in advance of the project for other purposes. The databases required included:

- all train, tram and bus timetables in digital format
- all train tram and bus routes in GIS format
- all train stations in GIS format

- all tram and bus stops in GIS format
- all cross-streets on tram and bus routes in GIS format

Several of these databases had to be updated for the project, while a new train timetable was introduced in the middle of the survey period which necessitated the re-assembly of the train timetable database.

Given the scale of the survey, a significant effort went into the recruitment and training of field surveyors and data enterers. Many of the surveyors had worked for the TRC on previous public transport survey projects, but a substantial number of new recruits were also needed. In total, nearly 100 field surveyors were required on the books, with twelve of them working on any one day. In addition, another twelve people worked over two daily shifts on data entry and editing, while two full-time supervisors, two full-time programmers and six part-time analysts worked on the preparation of survey materials and the analysis of survey data.

A major preparatory task was the design of rosters to be used in the field. For each train, tram and bus route, the digital timetables were analysed to produce feasible work rosters to be used in the field. Starting around 6.45am, the rostering program found a sequence of trips which surveyors would follow on any particular survey day. The rosters considered the desired starting and ending places for the daily work (generally rosters started in the suburbs and ended in the suburbs in order to catch an a.m. peak trip to the city and a p.m. peak trip away from the city), an allowance for a meal break in the middle of the day (particularly at locations where eating and toilet facilities were available), and a limitation of the length of unbroken work periods. For each route, a series of weekday, Saturday and Sunday rosters were produced, each with a different starting time in the morning and covering a different series of runs. These rosters were then used in rotation on repeat surveys on any one route.

The assembly of work packets for the surveyors was a major task, given the continuous nature of the surveys and the tight timelines for completion of the project. Two supervisors worked full-time on the preparation of these work packets (containing rosters, timetables, questionnaire forms, Interview Control Sheets, incentive pencils, PUTRAS Newsletters, and administrative paperwork), the allocation of work to survey teams, maintaining communication with all survey staff, answering phone calls from surveyors and the general public, and conducting field audits of surveyors' performance.

DATA CODING & EDITING

The conduct of the survey, while complex, was merely the start of a data management process which resulted in the production of the final results. As questionnaires were allocated to specific surveys, their status was recorded in a Returns Log database, which tracked their movement and status over the course of the survey. When Interview Control Sheets were returned to the survey office after completion of a survey, the status of each

questionnaire was updated to reflect the fact that it was either unused, a refusal of one type or another, or was distributed and now had a pending status. As questionnaires were returned in the mail, their status was updated on a daily basis to reflect the fact that they were either valid returns or were confirmed as refusals.

Data from the Interview Control Sheets were entered via a data entry program written in Visual Basic. The data from each individual survey was initially stored in a separate Excel workbook with three worksheets; one for Control Sheet data, one for Ticket data and one for Trip data. As questionnaires were returned, the data for Tickets and Trips was added to this workbook via the Visual Basic data entry program. The master copy of this workbook was kept on the stand-alone data entry computer originally used for data entry for this survey, and the workbooks were backed-up on a daily basis to the network server. Numerous editing checks were built into the data entry program to maximise the quality of the data. Any problems that could not be resolved immediately by the data-enterer were "yellow-tagged" with Post-It notes for attention by the data entry supervisor.

Periodically, the data from all the workbooks on the network server were downloaded onto an analysis computer. They were then combined into weekly data files in a database format and read into FoxBase files for data manipulation and further editing. The FoxBase programs then output the edited data as sdf files ready for statistical analysis using SPSS. The SPSS programs produced numerous "integer cross-tab" tables which were then pasted into Excel templates which performed the final analyses and production of output tables and graphs.

WEIGHTING AND EXPANSION

An important part of the entire survey design was the calculation of weighting factors which would transform the raw data collected in the field surveys into information which gave a more representative picture of the entire population of public transport tickets. Remember that the PUTRAS survey was primarily a survey of ticket usage, where individual tickets were the unit of analysis. Therefore, it was important that the final weighted data should give as good a representation of the population of tickets as possible. The survey, itself, however did not use tickets as the sampling unit. It sampled passengers who boarded specific carriages on specific runs on specific routes on the Survey Day. This data was converted from non-representative passenger-based information to representative ticket-based information by means of a series of weighting factors as described below.

Route Weights

On a normal Survey Day, two train routes, two tram routes and two bus routes were surveyed. This represents only a fraction of the possible surveys on that day. In addition, because there are fewer train routes than tram routes than bus routes, individual train routes were surveyed more frequently than individual tram routes or bus routes. The Route Weights

corrected for this sampling bias by applying a weighting factor representing the average number of days between surveys on any specific route. This factor was calculated from a table of survey frequencies for each route and a table of total days operated on each route within the quarter.

Run Weights

Within a Survey Day, not all runs were surveyed on the selected routes. Depending on the length of the route and the average headway, the proportion of runs surveyed during the day could vary substantially. Longer, more frequent services needed a larger Run Weight to have them represented appropriately in the sample. The Run Weights were calculated for each roster used on the route, by time of day (a.m. peak, off-peak, and p.m. peak) and by day of week (weekday, Saturday and Sunday).

Carriage Weights

On trains, only one carriage was surveyed on any Survey Day. This carriage was systematically rotated during the course of the survey period. The number of available carriages was also recorded for each run (normal peak-hour services have six carriages, some off-peak services have only three carriages, while other off-peak services have some of the six carriages closed to the public for security reasons). The Carriage Weight was set equal to the number of available carriages on each run to represent the total number of passengers boarding the entire service. All surveys on articulated trams were conducted in the front section of the tram, and a carriage weight of 1.5 was used to reflect the unequal distribution of boarding passengers between the front and rear sections of articulated trams.

Passenger Selection Weights

During the survey, surveyors were instructed to select one in every x passengers boarding the vehicle for receiving a questionnaire. The value of x was pre-specified by the survey design team to reflect anticipated passengers boardings, such that an adequate balance was maintained between surveyor boredom and surveyor overload. In general, smaller values of x were used on off-peak and counter-peak runs and larger values on peak-hour peak-direction runs. This means that peak-hour peak-direction passengers would tend to be under-represented in the data. The Passenger Selection Weights corrected for this by calculating a weight which was usually equal to the value of x on each run. This weight varied sometimes, however, to reflect any accidental deviations from the specified value of x, any periods where the survey was suspended because of gross overloading of the vehicle which prevented the surveyors from reaching the designated passenger, or any passengers who boarded the vehicle before the surveyors at the origin station.

Response Rate Weights

On average, the response rate to the survey was 23%. This response rate was lower than expected (the Pilot Survey obtained a response rate of 32%), mainly due to bad publicity surrounding the introduction of Automatic Ticketing Machines at the same time as the commencement of the survey. The response rate for each run, however, varied from about 10% up to 50% of selected passengers. To reflect these overall differences in response rate, therefore, a Response Rate Weight was calculated for each route as the inverse of the response rate obtained on that route. Other variations in response rates are accounted for by later weights.

Multiple-Trip Weights

While the focus of the analysis was on tickets, the sampling unit was boarding passengers. Tickets which were used more during the day were more likely to be selected since they "boarded the vehicles" more frequently than tickets that were used less frequently during the day. Therefore, each observed ticket had to be weighted by the inverse of the number of times it was used during the day. More specifically, it had to be weighted by the inverse of the number of times it was used during the hours when the PUTRAS survey was being conducted (from 7 a.m. through 6 p.m.) and was therefore capable of being observed.

Overall Trip Weights

The above six weights were calculated from the PUTRAS files and the public transport databases, and then attached to each record in the Trip database. A Trip Weight was then calculated as the product of the six weights. The mean and variance of this Trip Weight was then calculated for each property, and outliers were censored using a Windsorising process which set values greater than the mean plus three standard deviations equal to the mean plus three standard deviations. This Windsorising process was useful in making the expanded results more robust by protecting the final results from the effects of any statistical outliers. The various analyses were then repeated using these overall Trip Weights to obtain estimates of the expanded population results.

Demographic Weights

One of the design features of the PUTRAS survey was the inclusion of a detailed observational survey which recorded characteristics of all the passengers who were selected to receive questionnaires, irrespective of what then happened to those questionnaires. In particular, the age and sex of the passenger and the ticket type and ticket zone were recorded wherever possible (ticket details were often not recorded for selected passengers who got off the vehicle before the surveyor could get to them, even though age and sex usually were recorded for these passengers). The purpose of recording this information was to see whether

these characteristics were the same for survey respondents and non-respondents, and, if not, to calculate weights to correct for these differences.

The Demographic Weights based on a comparison of the Trip-Weighted demographic profiles (age and sex) obtained from the Interview Control Sheet (the observational survey) and the Ticket file (the questionnaire responses) are shown in Figure 1. A high value of the weight (such as for males under 15) indicates an under-response from that group to the questionnaire survey, which necessitates an increase in representation in the expanded data.

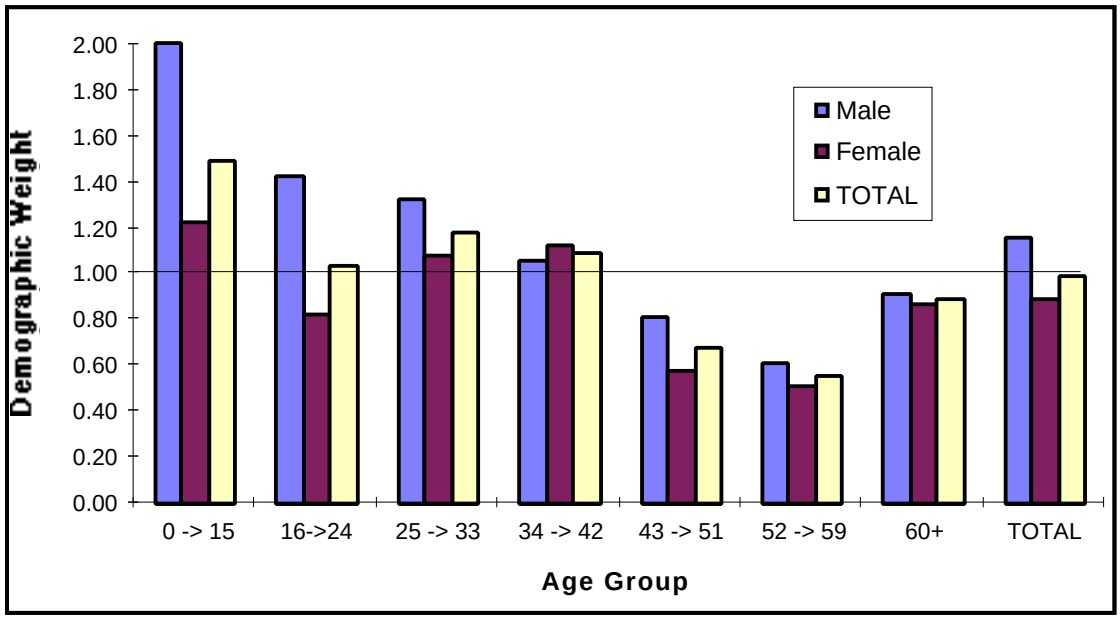

Figure 1 Demographic Weights after Trip-Weighted Analysis

Ticket Weights

After application of the Demographic Weights, the analysis was repeated to determine if there was any remaining bias with respect to ticket type and ticket zone as measured in the observational and questionnaire surveys. The Ticket Weights based on a comparison of the Demographic-Weighted ticket profiles (ticket type and zone) obtained from the Interview Control Sheet (the observational survey) and the Ticket file (the questionnaire responses) are shown in Figure 2 for various Ticket Types and in Figure 3 for various Ticket Zones.

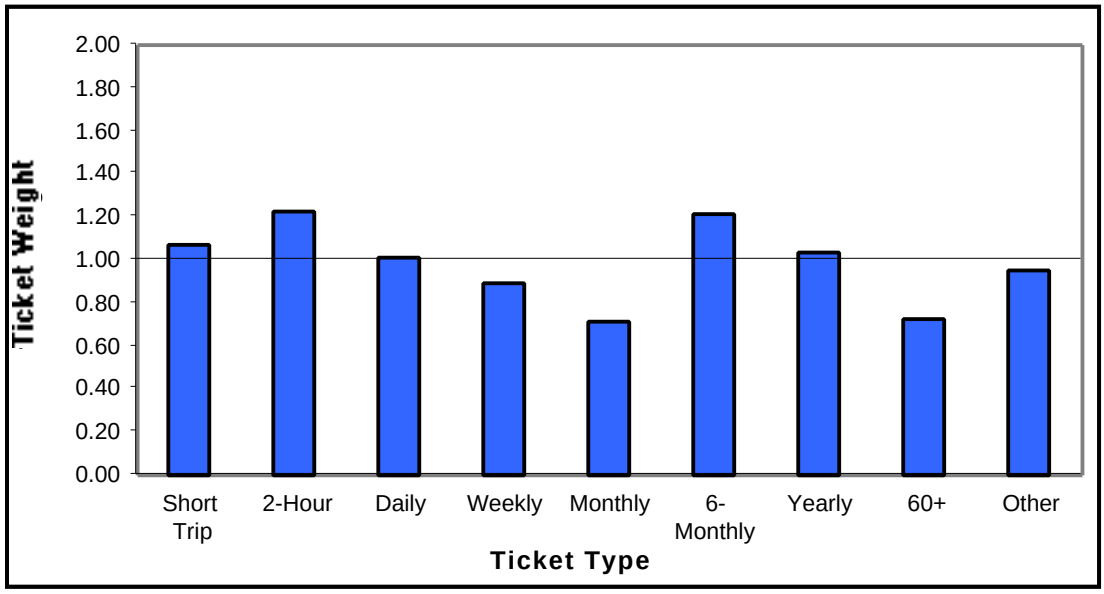

Figure 2 Tickets Weights by Ticket Type after Demographic-Weighted Analysis

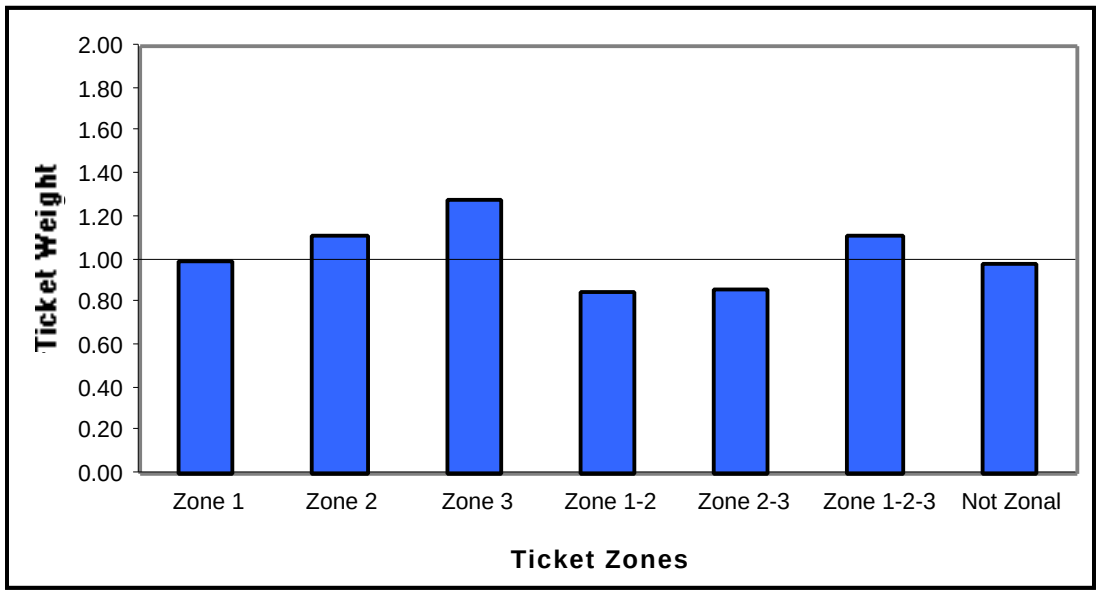

Figure 3 Tickets Weights by Ticket Zone after Demographic-Weighted Analysis

A high value of the ticket weight indicates an under-response from that ticket type to the questionnaire survey, which necessitates an increase in representation in the expanded data. Figure 2 shows that weekly, monthly and 60+ tickets tended to be over-represented in the questionnaire survey responses, while Figure 3 shows that multiple-zone tickets tended to be more represented than single-zone tickets, and inner-zone tickets tended to be more represented than outer-zone tickets.

Out-of-Hours Weights

The final set of weights were required to account for the fact that the PUTRAS survey was not conducted at all hours of the day and night. For economic, and surveyor security, reasons, the surveys were only conducted between the hours of approximately 7 a.m. and 6 p.m. From analysis of the VATS data, it was found that these hours accounted for the possible sighting of approximately 95% of all tickets. However, it was expected that those tickets which could not be sighted, such as those used for the first time after 6 p.m., would not be evenly spread across the properties since, for example, buses run many fewer night services than either trains or trams. Therefore, using the VATS data, a set of mode-specific weighting factors were derived to account for those trips which could not have been sighted during the survey period.

SOME RESULTS

The application of the above weighting factors to the data obtained from the questionnaire replies enables the calculation of ticket usage rates which are representative of the public transport system as a whole. This final section of the paper gives some of the results of the PUTRAS survey in terms of ticket usage rates.

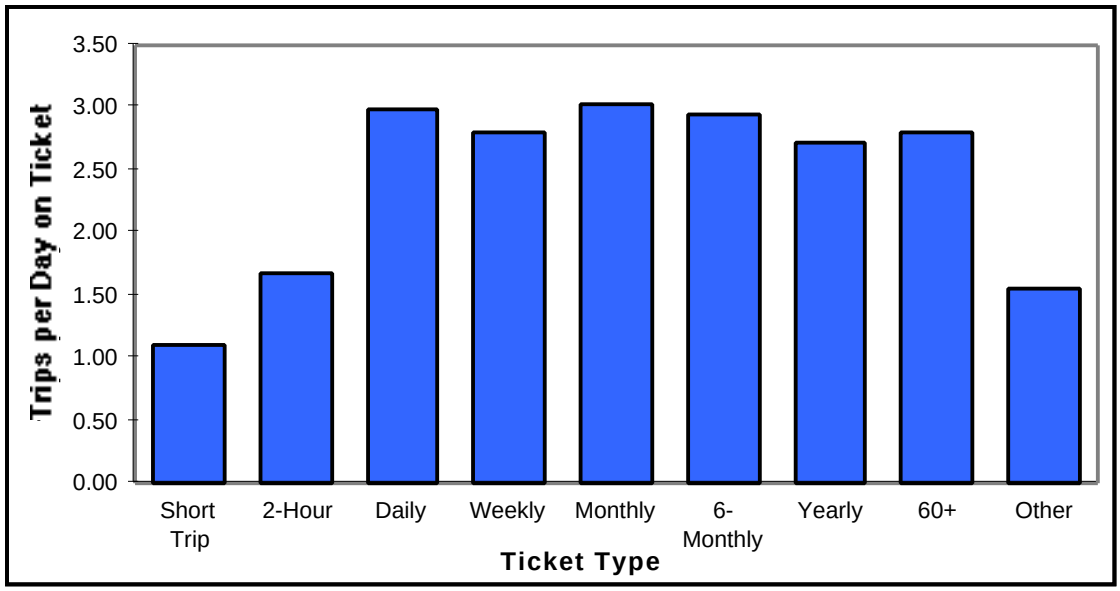

Figure 4 Trips per Day on Ticket by Ticket Type

The number of trips made on a single ticket on the Survey Day ranges from a low of 1.1 for a short trip ticket up to about 3.0 for several of the longer period tickets. The figure for the short trip ticket is interesting since they are only supposed to be used once; obviously, however, people are using them more than once on some occasions (which is known anecdotally to be the actual case). There is very little variation for any of the longer period tickets which can be used all day. It would appear that, in Melbourne at least, the length of

validity of a ticket, beyond a day, has no effect on the daily use of the ticket. This contrasts with recent results obtained by Axhausen et al. (1998) in a survey of ticket usage rates in Europe, where they concluded that longer validity tickets tended to be used less intensively.

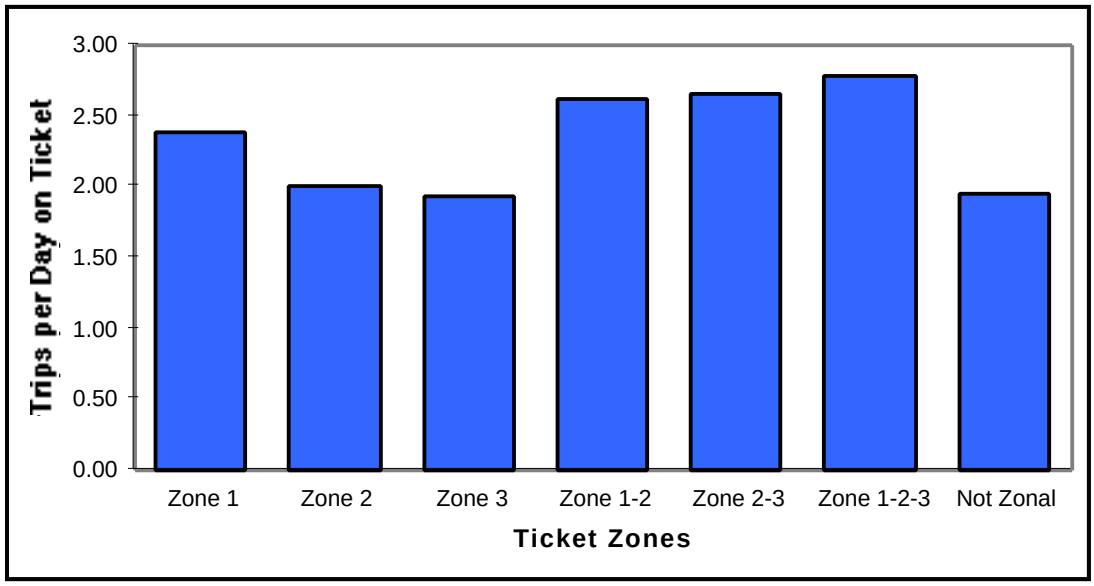

Figure 5 Trips per Day on Ticket by Ticket Zone

As shown in Figure 5, the number of trips per day on tickets for different zones shows that, for single zone tickets, the number of trips per day is highest in the inner zones whereas, for multiple zone tickets, the number of trips per day is highest for tickets valid in the outermost zones. Non-zonal tickets have the lowest usage rates.

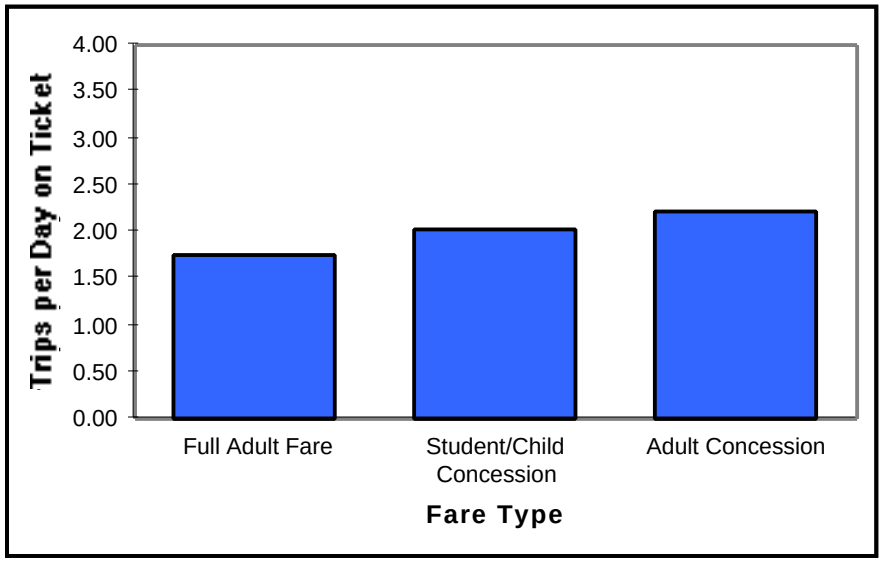

Figure 6 Trips per Day on Ticket by Fare Type

Full adult fare tickets are used less often than either student concession or adult concession tickets, as shown in Figure 6. This has interesting implications given that concession tickets also cost about half of the full fare ticket.

Overall, males tend to use their tickets more, especially older males, as shown in Figure 7. The highest ticket usage rates are for those travellers in their teens and early twenties, with middle-aged travellers having the lowest usage rates.

Figure 7 Trips per Day on Ticket by Age Group and Gender

Many of the differences in ticket usage rates are related to the employment status of travellers. As shown in Figure 8, those in full-time employment use their tickets less than those either in part-time employment or those who are not employed at all. Quite simply, those who are working full-time have less time available in which to be travelling.

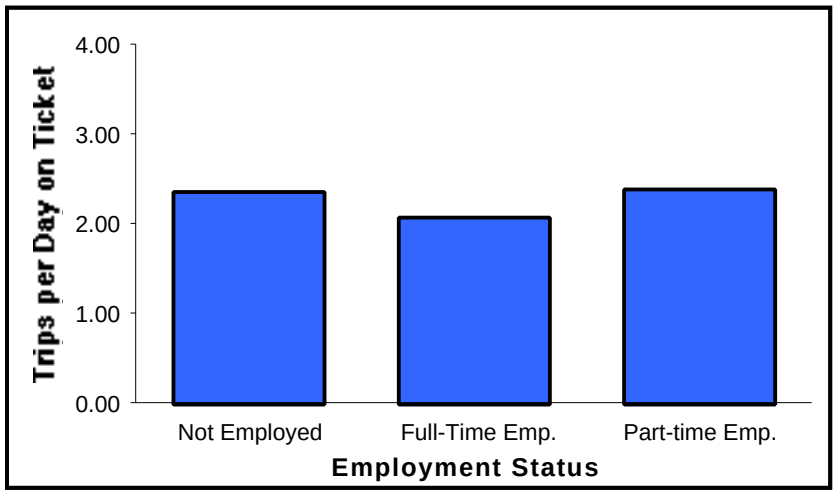

Figure 8 Trips per Day on Ticket by Employment Status

Clearly, much more detailed analysis of ticket usage can and will be performed on the PUTRAS data set. However, such analysis is beyond the scope of this paper, whose prime intention was to concentrate on the methodological aspects of the survey.

CONCLUSION

This paper has described a survey technique which has been used for the measurement of public transport ticket usage rates. The objective of the survey was to provide information to assist in the allocation of fare-box revenue to operators within a privatised public transport framework. The method has been shown to work successfully and, by comparison with other data sources, to provide credible estimates of ticket usage.

A principle methodological aspect of the survey was the need to recognise, in advance, that the sampling method was not truly representative, and that extensive weighting would need to take place in order to obtain unbiased population estimates. In order to do this, specific information needed to be recorded before and during the survey, rather than waiting for the analysis phase before realising the need for weighting data. Similarly, the use of multiple survey methods (ticket usage questionnaire and observational survey) was necessary in order to obtain an estimate of the effects of non-response bias.

The PUTRAS survey is continuing on an ongoing basis beyond mid-1998 (when this paper was written). It will be used on an ongoing basis in the revenue allocation process, and will also provide an unprecedented source of information on public transport usage patterns in Melbourne.

REFERENCES

Axhausen, K.W., Köll, H. and Bader, M. (1998). Public Transport Usage Intensity of Season Ticket Holders in the City of Innsbruck. Report to the Innsbrucker Verkehrsbetriebe GmbH