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Analysis of Inland Mode Choice Decisions and Travel Characteristics of Air Passengers: A Case Study in Bandaranaike International Airport (BIA)

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Abstract: The study delves into understanding the inland travel behaviour pattens of air passengers and estimate their respective mode choice parameters. Data collection process involved conducting face to face survey with both arrival and departure air passengers at Bandaranaike International Airport (BIA). Multinomial Logit (MNL)modelling approach was adopted for the estimation of mode choice probabilities of the selected parameters. RStudio platform was utilized for the parameter estimation. For the study, total travel time, travel cost and distance were considered as main parameters and estimated under the utility maximization theory. Total travel time and travel cost were found as significant parameters while total travel time was the most significant. The study concluded that the air passengers have given more priority on travel time than travel cost or distance when choosing an inland travel mode for reaching and leaving the airport. Estimated Alternative Specific Constants (ASCs) confirmed that self-arranged car is the most preferable option followed by Uber/PickMe taxi services and private taxis. Meanwhile, van/jeep has become the less preferred option in comparison with the public bus.

Keywords: Air passenger, Multinomial Logit model, Mode choice, Parameter estimation, Inland travel behaviour

1. Introduction

People pay more attention when they fly overseas due to the special procedures involved in air travel. Departing passengers must arrive at the airport well before their scheduled departure time in order to complete necessary procedures, such as security checks and immigration clearance. Similarly, arriving passengers prioritize a safe journey from the airport to their destination. Consequently, planning the inland component of the journey is crucial as the air journey itself. Inland trip is often a planned journey, requiring passengers to make decisions based on various factors. For understanding the importance and priority of these factors necessitates a comprehensive parameter estimation. Several studies have examined the factors influencing passengers' mode choice decisions and implications for airport access planning and policymaking. Jou et al. (2011) investigated airport ground access mode choice behaviour after an introduction of a new mode at Taoyuan International Airport in Taiwan [1]. Their main findings indicated that out-of-vehicle and in-vehicle travel times are two dominant factors that affected the outbound air traveller's choice of airport access modes, with time-savings, no transfers and convenience of storing and retrieving luggage being important considerations.

By examining the mode choice preferences and considerations of air passengers accessing the Bandaranaike International Airport (BIA), insights were gained to investigate their decision-making process, including their inland travel behaviour patterns, factors affecting their mode choice and estimating those parameters using Multinomial Logit (MNL) modelling approach.

BIA is situated 32 km north of Colombo, stands as the principal and busiest airport in Sri Lanka, playing a pivotal role in connecting the island to global aviation networks. Managed and operated by Airport and Aviation Services Limited (AASL) since 1983, the airport oversees operational, maintenance, navigational, and safety aspects, providing crucial services to both passengers and

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airlines.BIA caters to over 10.8 million annual passengers with 31 airlines facilitating airport and aviation services. This strategic location, vital role, and extensive services rendered by BIA underscore the significance of understanding air passenger behaviour for optimizing airport access.

The aim of this study is to identify the inland travel behaviour patterns of air passengers and estimate their respective mode choice parameters by MNL modelling approach. Primary objective is to identify the travel characteristics of air passengers, analyse the factors influencing their mode choice decisions, and estimate the mode choice parameters.

This study is uniquely focused on the specific context of BIA, with data exclusively collected from both arrival and departure passengers through face-to-face interviews. The scope of the study is limited to air passengers, and sampling was done excluding accompanying family members or individuals in groups traveling who were not directly involved in the decision-making process to ensure the specificity of the collected data for the analysis of mode choice decisions of air passengers accessing BIA. Modelling and analysis were conducted in RStudio platform, allowing for the estimation of mode choice parameters based on the collected data. Through this comprehensive approach, the study seeks to contribute insights into the decision-making process of air passengers, including their inland travel behaviour patterns and the factors influencing their mode choice at BIAwhich have not been addressed previously with such a modelling approach for the best of knowledge of the authors.

2. Literature Review

Jou et al. (2011) examined the airport ground access mode choice behaviour after an introduction of a new travel mode at Taoyuan International Airport in Taiwan. They investigated the mode choice behaviour of air passengers departing from Taiwan and traveling overseas, focusing specifically on the airport ground access [1].

2.1 Survey methods

Akar (2013) used a survey-based approach to investigate ground access to Port Columbus International Airport, USA. For just one day, the research team was permitted to interview those waiting at the gates, using paper surveys. Both arriving and departing flight travellers were targeted during the survey [2].

Alhussein (2011) analysed ground access mode choice at King Khaled International Airport (KKIA) in Riyadh, Saudi Arabia. Due to the unavailability of readily accessible data on traveller and transportation system characteristics, a survey questionnaire was conducted over a period of three days. A semi-random distribution method was used where the questionnaire was given to the first person in the first row of the boarding waiting area and subsequently every fourth traveller [3].

2.2 Modelling techniques

Gokasar and Gunay (2017) investigated the mode choice for ground access to Istanbul Airport (IST) in Turkey using the MNL modelling technique. Four modes considered in the study were auto, drop-off, public transit, and taxi. Unique aspect of the work was examination of the influence areas of public transit systems in Istanbul on the mode choice for accessing the airport [4].

Tam et al. (2011) researched on the impact of travel time reliability and perceived service quality on airport ground access mode choice. The work focused on the application of MNL modelling technique in analysing airport ground access mode choice. The study utilized data from modal split surveys, combining both Revealed Preference (RP) and Stated Preference (SP) responses to develop a comprehensive mode choice model [5]. Furthermore, Pasha et al. (2020) developed a mode choice model for air passenger's ground access to Brisbane Airport using the Mixed Logit (MXL) model where authors utilized the PythonBiogeme 2.5 software to develop MNL and MXL models for analysing transportation choice behaviour. The models considered state-dependence, inertia and serial correlation effects [6].

3. Methodology

Methodology of the work is shown below in Figure 1.

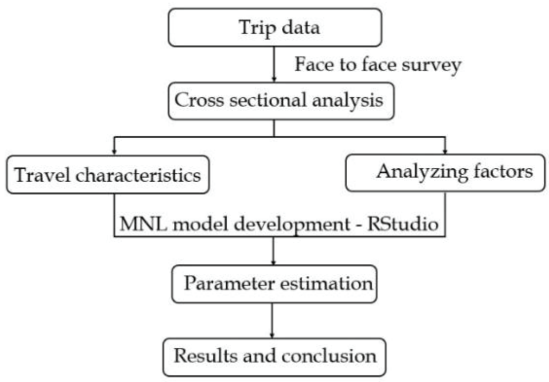

Figure 1 -Methodology flow chart

Data collection process entails face-to-face survey exclusively at BIA, targeting both departure and arrival passengers while excluding accompanying family members. MNL modelling approach was employed for parameter estimation, utilizing the RStudio platform for data analysis and modelling. MNL model allows the estimation of mode choice probabilities based on the collected data and identified parameters.

3.1 Data collection

Data collection at BIA was conducted as a face-to-face survey as paper survey and QR code survey. QR code survey was used as a data collection option due to several challenges and difficulties that arose in conducting the paper-based survey in the high security zone. Those were limited free time availability for travellers and to adhere the guidelines inside the airport. Hence, time constraints posed a major obstacle to the paper survey. Language barrier was another issue as some of the travellers from non-English speaking countries were a bit reluctant to involve in the interview.

QR code survey has been able to overcome the difficulties associated with paper surveys. In the QR code survey, we provided a printed QR code to the air passengers. This gave passengers access to a specially designed Google form for survey responses, by scanning the QR code. The approach allowed for greater convenience and flexibility, as travellers could complete the survey at their own convenience and change their preferred mode of data collection from paper to an electronic format. By leveraging technology and utilizing a user-friendly platform like Google forms, this method streamlined the data collection process, reduced time constraints, and addressed language barriers. Furthermore, it also provided passengers with the opportunity to maintain their privacy and ensured the accuracy and integrity of the data collected. However, only the responses received within a period of 24 hours were accepted to avoid any recall bias.

A total of 326air passengers participated in the survey, with 301 of them providing complete responses. Out of the collected sample, 183 were departures while 118 were arrivals. Data collection was conducted within a period of one month. Considering a monthly average of 750,000 passengers, the sample size was tested based on Solvin's formula.

$$n = \frac{N}{1 + NE^2} \qquad \text{... (1)}$$

where,
n = Sample size
N = Population
E = Error tolerance

Considering 94% confidence interval,

$$n = \frac{750{,}000}{1 + 750{,}000 \times (0.06)^2} = 278$$

Hence, our selected sample was well over the 94% confidence level.

Collected data were thoroughly examined in order to identify the travel characteristics of air passengers by using a cross-sectional analysis.

3.2 Theoretical background

Logit model is a commonly employed approach for estimating mode choice parameters in transportation research. In this study, we adopted MNL model, which is rooted in the utility maximization theory. MNL approach has developed based on three assumptions: (1) the error components are extreme-value (or Gumbel) distributed, (2) the error components are Identically and Independently Distributed (IID) across alternatives and (3) the error components are IID across observations/individuals.

MNL model allows to estimate mode choice probabilities by defining a utility function that expresses the satisfaction of trip makers with their mode choice. Utility function was formulated as a linear combination of selected independent variables, representing factors such as total travel time, travel cost and distance. By employing the MNL model, it is possible to quantify the influence of these variables on mode choice decisions and gain insights into the relative importance of each factor. The adopted utility function can be represented as,

$$U_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \ldots + \varepsilon \qquad \text{... (2)}$$

where, U_i is the utility of mode i, X_1, $X_2 \ldots X_n$ are the attributes of alternatives, β_1, $\beta_2 \ldots \beta_n$ are the respective parameters which define the direction and magnitude of the incremental bias due to an increase in the i^{th} characteristic of the decision maker. β_0 represents the parameter associated with the Alternative Specific Constant (ASC) and ε is the random error term.

Based on utility maximization, MNL model was used to determine the probability that the decision-maker would select an alternative k;

$$p(k) = \frac{e^{Uk}}{\sum e^{Ux}} \quad \text{... (3)}$$

where, p(k) is the probability of a passenger selecting an alternative k and U_k is the utility of alternative k.

Log-likelihood function was maximized for the parameter estimation. Probability of a person n choosing the alternative that he/she was actually observed to choose from a sample of N decision-makers can be expressed using equation (4).

$$\prod_i (p_{ni})^{y_{ni}} \quad \text{... (4)}$$

where $y_{ni} = 1$, if person n chooses i^{th} alternative and zero otherwise. So, this simply gives the probability of the chosen alternative.

Assuming that each decision-maker's choice is independent of others, the probability of each person in the sample choosing the mode that he/she actually using is calculated from equation (5).

$$L(\beta) = \prod_{n=1}^{N} \prod_i (p_{ni})^{y_{ni}} \quad \text{... (5)}$$

where β is a vector containing the model parameters. The log-likelihood function is expressed as in equation (6).

$$LL(\beta) = \prod_{n=1}^{N} \prod_i y_{ni} \ln(p_{ni}) \quad \text{... 6)}$$

Likelihood ratio index (ρ^2) was used to determine the goodness of fit for the model. Likelihood ratio index is calculated as;

$$\rho^2 = 1 - \frac{LL(\hat{\beta})}{LL(0)} \quad \text{... (7)}$$

where,($\hat{\beta}$) is the final value of the log-likelihood function at the estimated parameters and LL(0) is the respective value when all the parameters are set equal to zero (initial value).

Likelihood ratio index is improved with the increase of number variables, even though the variables do not have any relationship with the output results. Accordingly, the adjusted likelihood ratio index ($\bar{\rho}^2$) is considered and it can be expressed as;

$$\bar{\rho}^2 = 1 - \frac{LL(\hat{\beta}) - k}{LL(0)} \quad \text{... (8)}$$

where k is the number of degrees of freedom (parameters) used in the model.

t-statistic values are used to determine the significance of the predicted parameters.

$$t - statistic = \frac{\hat{\beta}_k - \beta^*_k}{S_k} \quad \text{... (9)}$$

where$\hat{\beta}_k$is the estimate for the k^{th} parameter, $\beta^*_k$is the hypothesized value for the k^{th}parameter and S_k is the standard error of the estimate.Additionally, t - statistic approach was employed to test and validate each parameter separately. A parameter is considered over 95% significant if the numerical value of the t- statistic is over 1.96.

3.3 Parameter estimation

Collected data categorized based on trip characteristics and selected model parameters for the estimation. RStudio platform was used for the parameter estimation based on the utility maximization.

4. Results and Discussion

4.1 Cross-sectional analysis

Collected data were thoroughly examined in order to identify the travel characteristics of air passengers through a cross-sectional analysis. In the overall data set, 60% passengers were departures while 40% were arrivals. In addition, 58% were male respondents while 42% were female.

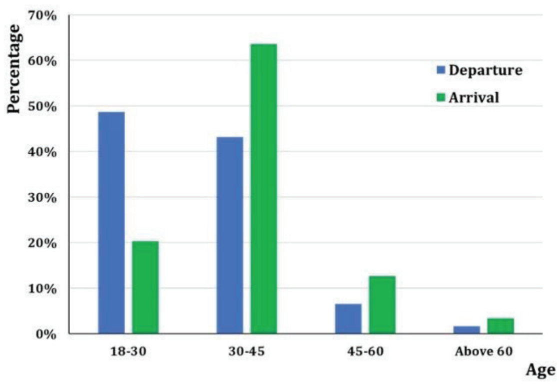

Figure 2 - Age variation of passengers

Figure 2, illustrates that most of passengers are below age 45, comprising 88.7%. Among them the highest proportion falls within 30-45 range of age, constituting 51.2%. While the largest number of departing passengers falls within the 18-30 age range, the greatest number of arriving passengers is in the 30-45 age category. Specifically, the percentages for those groups are 48.6% and 63.6%, respectively. Notably, the lowest percentages for both departure and arrival passengers are observed above 60 years of age accounting for 1.6% and 3.4%, respectively.

According to Table 1 and Table 2, regarding the occupational variation of the responded passengers, it is noteworthy that non-employed local arrivals are almost zero while 6% of the same were leaving the country. Employed category was the dominating party as expected and it is significant to note that around 10% foreign arrivals and local departures were entrepreneurs.

Table 1 – Occupational variation of arrivals

Occupation	Arrival air passengers (%)	
	Local (37.3)	Foreign (62.7)
Student	3.4	16.0
Non employed	0.0	0.9
Employed	28.8	33.9
Entrepreneur	2.5	10.1
Retired	2.5	0.9
Other	0.0	0.9

Table 2 – Occupational variation of departures

Occupation	Departure air passengers (%)	
	Local (90.2)	Foreign (9.8)
Student	32.2	4.4
Non employed	6.0	0.5
Employed	41.0	4.4
Entrepreneur	9.4	0.5
Retired	1.6	0.0
Other	0.0	0.0

Considering the average monthly income of the passengers, it is notable that over 50% local departures were below 100,000 LKR. Moving further inside, 27.3% of them had their average monthly income below 50,000 LKR. Meanwhile it was observed that the majority of the foreign arrivals had a higher income in between from 0.25 to 1 million LKR.

Table 3 – Average monthly income of arrivals

Monthly income (LKR)	Arrival air passengers (%)	
	Local (37.3)	Foreign (62.7)
Below 100,000	0.0	0.0
100,000 – 250,000	8.5	16.1
250,000 – 1,000,000	26.3	39.0
Above 1,000,000	2.5	7.6

Table 4 –Average monthly income of departures

Monthly income (LKR)	Departure air passengers (%)	
	Local (90.2)	Foreign (9.8)
Below 100,000	54.1	0.5
100,000 – 250,000	29.0	3.3
250,000 – 1,000,000	6.6	6.0
Above 1,000,000	0.5	0.0

Insights into the characteristics of air passengers and their travel purposes reveal departure passengers' inclination towards studying or working, while arrival passengers primarily engage in vacationing or visiting family and friends. Notably, those who were departing for education were typically under 30 years of age, whereas arrivals for vacation are mainly foreigners, and those visiting family or friends are local citizens.

Duration of stay is another key aspect with respect to both arrivals and departures. Most arrivals stay for less than 90days, suggesting short-term purposes such as vacations or family visits. In contrast, a substantial portion of departing passengers opts for longer stays, particularly in the range of 1-5 years, indicating a prevalence of educational or work-related commitments. The financial aspect of air travel was also touched upon, revealing that a significant majority of air passengers (93.7%) are self-funded.

Mode choice variability was the main aspect of the work. Accordingly, the respective variability was plotted and investigated.

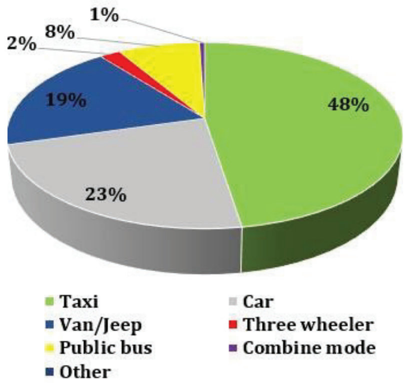

Figure 3 – Modechoice for reaching and leaving the airport

As Figure 3 shows,47.5% of air passengers accessing BIA and leaving from BIA to their accommodation use taxis as their main travel mode. In addition, 23% choose car, 19% select van or jeep which are arranged on a personal basis (owned by the passengers and their relatives) while8% use the public bus. Accordingly, it can be concluded that access and egress mode of airport is governed by the private sector.

When further scrutinized, it was revealed that68% arrivals use taxis while only 34% use the same mode when departing. This highlights that most arriving passengers are unable to arrange their egress mode before landing, and correspondingly they opt for selecting taxi for leaving the airport. However, when considering the departure passengers, their access mode is varying between different types of transportation modes like car, van, three-wheeler, and combine modes based on their diverse choice set which is not available when arriving. Uber and PickMe were the most famous taxi services among both arrival and departure passengers while PickMe was dominating.

Table 5 – Taximodes of air passengers

Taxi mode	Departure (%)		Arrival (%)	
	Local (70.2)	Foreign (29.8)	Local (14.3)	Foreign (85.7)
Airport taxi	0.0	0.0	2.6	11.7
Private	44.7	19.1	6.5	50.6
Uber	4.3	4.3	1.3	16.9
PickMe	21.3	6.4	3.9	6.5

Figure 4 shows a Likert scale analysis of air passengers. Results revealed distinctive priorities among air passengers when considering factors influencing airport access and egress.

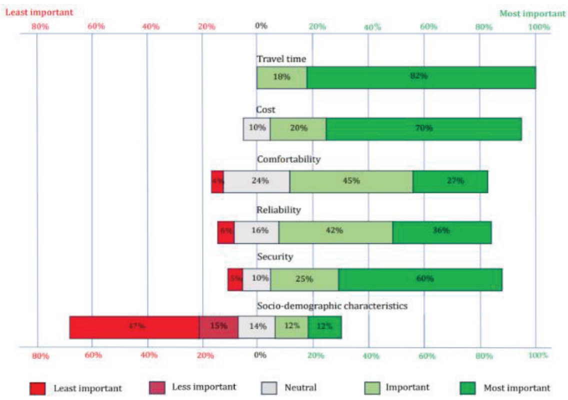

Figure 4 – Likertscale analysis

As per the above analysis, it can be identified that most important parameter when selecting an airport access and egress mode was travel time as per 82% of the respondents while rest of the 18% confirmed it is important too. Followed were the cost, comfortability, reliability and security. Meanwhile, socio-demographic factors were indicated as the least priority. Accordingly, the top 2 parameters were selected for the parameter estimation as travel time and travel cost.

4.2 Parameter estimation

Model development was done as explained in under section 3.2, in the RStudio platform. Model was developed with five mode categories as private taxi, Uber/PickMe, car, van/jeep and public bus. Use of all above modes were considered in the parameter estimation. ASCs were estimated by normalizing ASC_public bus = 0.Parameter estimation results are shown in Table 6.

Table 6 – Parameter estimation results

	Estimate	t value
ASC_Private taxi	1.75	2.15
ASC_Uber/PickMe	3.86	4.16
ASC_Car	9.13	3.44
ASC_Van/Jeep	-12.77	-2.75
Total travel time	-3.80	-3.09
Total cost	-0.01	-3.95
Sample size	301	
Rho-square	0.71	
Adjusted rho-square	0.68	

ASCs are important as intrinsic preference of each option is not explained by the parameters. In addition, systematic differences in utility across available alternatives are not captured by the observed features. Personal interests and habits, comfortability, family status, etc. can be influenced in this case. Accordingly, the comparative judgement of the estimated ASCs indicate that car is the more preferable option followed by Uber/PickMe and private taxi, respectively. Van/jeep is a less preferred option in comparison with the public bus. However, most of the respondents had highlighted the limited availability and facilities of the public bus transport in order to reach and depart from the airport.

Model fit was measured using the likelihood ratio index and the adjusted likelihood ratio index, which were found to be 0.71 and 0.68,respectively. These values indicate a significant level of agreement between the model and the data. Travel time, travel cost and distance were considered as main parameters and estimated through the MNL model. Travel time and travel cost were found as significant with 95% confident as the respective t-values are greater than 1.96 while distance was not significant. Among these significant factors, total travel time is the most significant factor. Accordingly, the air passengers have given more priority on travel time than travel cost or distance when choosing a travel mode for reaching and leaving the airport. The parameter distance becomes insignificant as it is corelated with the other two parameters as well as become a constant between the two ends of the journey.

5. Conclusions

Data collection process conducted face to face survey exclusively at BIA, targeting both departure and arrival passengers while excluding accompanying family members. A total of 326 air passengers participated in the survey, with 301 of these providing complete responses. Cross-sectional analysis indicated that most of travellers were below age 45 and they are employees and students. When considering the purposes of travelling, the main purposes of local departure passengers were working and education, while the main expectation of foreign arrival passengers was spending a vacation. Most departure passengers had a lower income while arrival passengers had a higher income. Regarding the returning time of responded air passengers, most of departees will return in 1–5 years while most arrivals will leave within 03 months. Furthermore, most travellers are self-funded and their airport access is dominated by private transport.

MNL model was used to estimate the model parameters based on utility maximization theory, with travel time and cost being found to be significant factors for mode choice. The study found that total travel time was the most significant parameter, as air passengers prioritize it over travel cost when choosing a mode of airport access/departure. ASCs indicated that self-arranged car is the most preferable option followed by Uber/PickMe taxi services and private taxi, respectively. Van/jeep is a less preferred option in comparison with the public bus. However, most of the respondents had highlighted the limited availability and facilities of the public bus transport in order to arrive and depart from the airport.

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