Time-of-day preferences for intercity air travel: Case - New Delhi, India

M. Manoj [a],[*], K. Ramachandra Rao [a], Arvind M. Jain [b]

[a] *Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India*
[b] *Officer on Special Duty (Academic section), Gujarat technological University, GTU campus Chandkheda, Ahmedabad -382424, India*

ABSTRACT

This paper investigates the preferred time slots of travelers flying from New Delhi to other major cities in India utilizing a revealed preference data. This paper presents the preferences for any one of the periods (Morning, Mid-Day, and Evening) as a binary choice model. Subsequently, the reasons for the choice of a particular time of day are explore and compared against the Morning time. The empirical models reveal that age, household income, the category of the route leading to the destination city, and trip purpose are some of the statistically relevant variables differentiating the preferences for any time slot against a specific one. In comparison, class of journey, gender, household income, and educational status are found to differentiate the choice among Morning, Mid-day, and Evening periods for the individuals who stated that they prefer to make the trip only during a specific period. The models imply that a respondent's age is found to influence the choice of a specific time. In contrast, the gender of an individual and trip purpose significantly affected the choices among Morning, Mid-day, and Evening periods. Based on the transferability of choice models over time, the study interprets the findings in terms of plans and policies for airline operators and airport authorities. The operators could gain inputs to planning trip schedules and infrastructure facilities in response to socio-demographic changes.

1. Introduction

Air travel is a dominant mode for domestic travel in many emerging Asian countries (Carnis and Yuliawati, 2013; Barros et al., 2017; Chaouk et al., 2019). Indian domestic air travel market has witnessed rapid growth in the past few years (Verma et al., 2018). The nation has 91 licensed airports, as per 2018 data, and 80 of them are under the public use category (Directorate General of Civil Aviation, n.d. (a)). Between 1997 and 2017, the (annual) domestic passengers carried by Indian carriers has increased from 11,545 (in 1997–98) to 103,748,598 (in 2016–17) (Directorate General of Civil Aviation, n.d. (b)). India is one of the largest (domestic) civil aviation markets in the world (Alexander and Merkert, 2018), and between the years 2011–2012, seventy-five percent of the passengers of Indian airports were domestic travelers (National Transport Development Policy Committee, 2014). By 2020, the passenger traffic at Indian airports would be 1.6 times that in 2016–17 and the nation would become the third-largest aviation market globally (India Brand Equity Foundation, 2018). The increase in aviation demand would be mainly due to the rising working population, the emerging middle class, and business and leisure travel (India Brand Equity Foundation, 2018). Hence, understanding traveler composition and

passenger evaluation of airline services would be the key to planning aviation infrastructure and airline schedules to cater to the future aviation demand in Indian cities.

Passenger perceptions (and evaluations) of air travel and airline operations can provide critical information to the planning and operation of aviation facilities. For example, passenger perceptions about service quality could influence personal recommendations and publicity and low-cost airlines' market reputations (Liu and Lee, 2016). It has been summarised that the class of journey and passengers' nationality is related to the perception of service quality (Park, 2007). The 's*oft*' aspects related to air travel are related to the age of traveler, air travel frequency, annual flight trip expenses, and purpose of travel (Lee et al., 2018). Passenger perceptions can also influence an airport's value (Zimmermann et al., 2018), airport service quality (Pantouvakis and Renzi, 2016), and individuals' intentions to travel by air (Cho et al., 2018).

As evident from the existing research, passenger characteristics are correlated with air travel demand and evaluation of airline services. In a comparative study conducted using Taiwanese data, Lu (2017) observed significant variations between the travel characteristics of passengers flying on full-service and low-cost airlines. Full-service carriers were

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most preferred for business and tourist trips, and those who flew alone or with friends or colleagues chose low-cost airlines. Airline mix and airline policies influenced the profile of passengers using different carriers. Cho and Min (2018) conducted a longitudinal analysis and found that passengers' profiles (age, income, etc.) of low-cost airlines and non-low-cost carriers in the U.S. are different. Some of the differences were explained by the costing and other policies adopted by airline operators. Chang and Sun (2012) found that age, gender, and income significantly influenced carriers' choices in the China-Taiwan sector. In a study conducted in Australia to ascertain business travelers' flight choice behavior, Wu and So (2018) observed that self-funded business travelers were more sensitive to ticket costs. In contrast, business travelers attributed higher values to flight amenities. Passenger characteristics also influence satisfaction with an airport. Using Brazilian data, Bezerra and Gomes (2018) performed an econometric analysis to investigate the influences of passenger profiles and airport quality dimensions on overall satisfaction with an airport. Passenger characteristics such as annual trip frequency and airport arrival concerning flight departure were significantly correlated with 'overall satisfaction.' The recent studies also reveal that passenger attitudes also play a role in air travel. Using a Swiss dataset, Enzler (2017) concluded that, apart from household context variables, attitudinal factors related to the environment also impact the choice of flight for private trips.

While past studies reveal that passenger characteristics and perceptions could inform airport infrastructure and airline operations policies, most of them focused on impacts of passenger mix and traveler perceptions on the airports, carriers, and routes. Limited research has been undertaken on the time-of-day preferences, and even fewer considered the geographical setting considered here, intercity travel in India. Recent studies have shown that departure time impacts itinerary shares (Coldren and Koppelman, 2005). For instance, passengers are found not to prefer early morning and late evening itineraries, as discussed in Koppelman et al. (2008). Borenstein and Netz (1999) noted that departure time differentiation is low when competing operators serve routes than single operators. While there is no comprehensive study on what influences passengers' departure time preferences, departure time has found applications in itinerary choice models (Wen et al., 2020). Earlier studies have also attempted to improve the representation of departure time functions (e.g., Grammig et al., 2005). Many studies have adopted continuous departure time representation in the itinerary choice analysis (Carrier, 2008; Koppelman et al., 2008). Wen et al. (2020) found that a trigonometric representation of departure time choices adequately captured passengers' time-of-day preferences in Taiwan. A continuous representation of time-of-day of flight departure improves model specification (e.g., Carrier, 2008). These findings were confirmed by Lurkin et al. (2018) and Koppelman et al. (2008). Lurkin et al. (2018) adopted a continuous representation of departure time using Sine and Cosine functions. The study noted greater competition between choice alternatives sharing identical departure times using a ticket database collected in the U.S. Brey and Walker (2011) undertook a joint analysis of departure time distributions and itinerary choice using a joint modeling approach. The departure time distributions were specified as a mixture of normal distributions and trip attributes, and socio-demographic features were correlated with time-of-day preferences. The study noted variations in departure time distributions by travel party composition and crossing of time zones. Also, the study noted heterogeneity in departure time choices and their association with travel purposes (Brey and Walker, 2011).

Overall, the available literature on departure time preferences indicates that time-of-day preferences impact itinerary choices. Studies have noted that departure times vary by trip makers' trip characteristics and background (e.g., Brey and Walker, 2011). However, studies assessing time-of-day preferences are very few and have not controlled for route characteristics and travelers' attitudes. Urban travel behavior research has noted that analysis of preferred time-of-day choices provides input to planning and policy (Börjesson, 2008). However,

preferred departure time choices in air travel and its association with flyers' trip characteristics and backgrounds have received little attention in the literature. The present research addresses this question through a study conducted in Delhi, India.

1.1. Research focus

This paper explores the preferred time of day for intercity travel by air. Schedules constrain the time of day for travel. In other words, departure time choice results from an individual's decision-making based on airlines' schedules and costs. However, the preferred time of day for travel shows an individual's actual alternative of time for trip-making, given their socio-demographics and travel needs. The actual choice may not include airline features (price, frequency, no. of stops), which in most cases are 'constraints' from an individual's standpoint. Thus, advanced information on the preferred time for air travel is beneficial for airline operators and airport authorities. Notably, such information can help operators plan airline schedules and devise schemes and offers based on trip makers' socio-demographic context. Implicitly, the plans for better utilization of infrastructure facilities, such as boarding gates and luggage belts that remain unused during specific periods in many airports could be made by understanding preferred time-of-day trip making. Limiting operations to a specific period (typically peak hours) could also lead to operational issues (Herring et al., 2019). Hence, the present study investigates the preferred time slot for intercity air travel and examines the roles of socio-demographics, trip contexts, and route categories. The main contributions of the research are threefold. *First*, the research contributes to the broad area of intercity travel, less researched, particularly by air. While most travel behavior studies in the literature emphasize urban travel, relatively less has researched intercity travel, particularly by air. *Second*, the study explores the domestic air travel context of the developing country, India. Over the past years, the domestic air market has been witnessing significant changes in India. However, relatively little research has been undertaken to investigate the demand side of air travel in India. *Third*, the study focuses on the preferred time for a trip than the actual (revealed) choice. Investigation of this aspect is rarely undertaken but is highly relevant for both airline operators and airport authorities.

With this background, the remaining contents of the article are organized as follows. The next section describes the study area and empirical data, and the statistical model is discussed in Section 3. Section 4 presents the model estimation results and discusses the broad implications of the study finding for planning. The last section summarizes the paper and concludes the article.

2. Research data and study location

The trips originating from the national capital (of India), Delhi, are the focus of the current research. Delhi has historical importance and, at the same time, caters to many administrative activities. The city also hosts industrial and service activities such as information technology (I. T.), telecommunication, banking, media, and life sciences. Due to this and its size, the city handles substantial domestic and international air traffic (the 2011 Census, the latest available, indicated a population of 16.78 million, Planning Department, n.d.). The trip information of travelers flying from the international airport in Delhi to other destinations in India is utilized for the present research.

The data were gathered through an intercept survey conducted in the departure lounges of Terminals 1A and 1B of Delhi International Airport Limited (DIAL) from early morning to late night (Jain and Rao, 2009). Before the primary survey, a pre-pilot study was undertaken to calibrate the survey instrument. The final data were gathered between June 2007 and May 2008. The respondents were randomly interviewed at the departure gates of the airport. The survey participation was voluntary, and there were no rewards involved in the survey. The volunteers explained the survey's purpose and contents, and those who agreed to the survey

were interviewed. Based on cost restrictions, the target sample decided was 2800 respondents, and 2661 out of 2800 respondents provided useful information. The response to the survey was mixed. Highly educated individuals and female travelers welcomed the survey, whereas the passengers whose flights were delayed were relatively disinclined to respond. Although is old, the dataset identified socio-demographic determinants of air travel relevant to practice, and no recent attempts was undertaken to replicate the study to date.

The data had been generated through a revealed preference (RP) survey questionnaire. The questionnaire captured information related to four main aspects: Household socio-demographics, person socio-demographics, trip-related details, and level of agreement with specific attitudinal questions. The household socio-demographics section mainly captured household-level information such as family size, vehicle ownership, and annual household income, among others. Age, gender, education background, etc., were captured under person socio-demographics. Trip details of an individual included information on trip destination, flight departure time (revealed time), access/egress trip details, ticket cost, class of journey, and booking history. This section also had a field to record the preferred time-of-day for flying — the responses to the question on the preferred time-of-day form the dependent variable for the present study. Finally, the respondents' level of agreement (on a Likert-type scale) with statements such as 'Air-tickets are easily available,' 'Flights operate at convenient timings,' 'Air-tickets are available at affordable prices,' etc. were also captured in the questionnaire. Further details on data - regarding sampling, survey administration, descriptive analysis on relevant variables, etc. - are available in Jain and Rao (2008) and Jain and Rao (2009). Fig. 1 shows the trip destinations reported in the study. The present study utilizes RP data to investigate the distribution of the preferred time slot for air travel as a function of socio-demographic and travel behavior variables.

3. Statistical model

This study employs the multinomial logit model (MNL), a widely applied discrete choice model, to study time-of-day preferences for intercity air travel. Discrete choice models describe an individual's decision about an alternative from a choice set of alternatives applicable to a particular choice situation. Since the dependent variables are qualitative (nominal) in the time-of-day choice analysis ("Morning," "Mid-day," etc.), discrete choice models are appropriate for the analysis of the decision-making process. The discrete choice models are derived from the concept of the utility maximization principle (Ben-Akiva and Lerman, 1989).

According to Ben-Akiva and Lerman (1989) and Koppelman and Bhat (2006), individuals choose an alternative that rewards them with the highest utility in a choice situation. However, the actual utility derived by the decision-maker is unknown to the analyst. An analyst can only partially explain the utility derived by the individual using the attributes of alternatives and socio-demographic characteristics of

Fig. 1. Trip destinations (Airports).

individuals. The lack of information on the analyst's part leads to the formulation of random utility models (Koppelman and Bhat 2006). According to the random utility theory, the utility that an individual 'n' gains by choosing an alternative 'i' from the choice set applicable to the choice situation is written as below:

$$U_{in} = V_{in} + \epsilon_{in} \tag{1}$$

Here, U_{in} is unknown to the analyst and is the actual utility gained by the individual in the choice situation. The analyst estimates V_{in} and is typically specified as linear-in parameters form. ε_{in} is the random component of the utility expression and equal to $U_{in} - V_{in}$. The analyst estimates the probability of utility of the alternative 'i' greater than that of the alternative 'j' (Equation (2)).

$$\Pr\left[\left(\varepsilon_{jn} - \varepsilon_{in}\right) \leq \left(V_{in} - V_{jn}\right)\right] \tag{2}$$

Equation (2) is the basis for most of the discrete choice models, and the MNL model is a special case of it. In the MNL model, the random terms are independently and identically Type-I extreme value (Gumbel) distributed. The probability expression for an MNL model is:

$$P_{in} = \frac{e^{V_{in}}}{\sum_i^k e^{V_{kn}}} \tag{3}$$

Where 'P' is the probability of choosing an alternative 'i' by individual 'n' from a choice set comprising of 'k' alternatives. If the choice set contains only two alternatives, i and j, Equation (2) reduces to a binary logit model (Equation 4).

$$P_{in} = \frac{e^{V_{in}}}{e^{V_{in}} + e^{V_{jn}}} \tag{4}$$

4. Empirical analysis

The behavior analysis has been undertaken in two stages. In the first stage, a binary logit model has been estimated to differentiate the travelers who prefer only a specific time [Morning (up to 10.00 a.m.) Mid-day (10.00 a.m.–5.00p.m.) or Evening (after 5.00p.m.)] from those who prefer any two or all of the periods for trip making. This analysis is crucial for the airline and airport authorities. It provides information on the socio-demographic groups with flexible travel schedules and helps design targeted policies to utilize airport infrastructure better. For example, some domestic airports have operational limitations (e.g., only a few flights afternoon). Depending on travel demand, efficient policies could be designed to improve the operating conditions. In the second stage, an MNL model is presented that models slot preferences of individuals who responded that they prefer only a specific time slot (Morning, Mid-day, or Evening) for trip making. Primarily, this part aims to model trade-offs made by respondents among the three time-of-day periods and explain them by including socio-demographics. The modeling exercise output also provides valuable information to the planning agencies since it depicts the temporal shift in travel demand (across three time slots) as a function of socio-demographic changes. This information is worthful for the airline operators and airport authorities as it can help them introduce new schedules and offer better management of airport facilities such as check-in gates and boarding bays. The following subsections present the empirical models in detail.

4.1. Binary Logit model estimation results

This section explains the binary logit model that differentiates the travelers who prefer only a specific time slot (Morning, Mid-day, or Evening) from those who like any two or all of the periods for trip making. Table 1 provides descriptive statistics of the variables appearing in the final model. About 78 % of the respondents prefer a specific slot for trip making. The sample suggests that nearly 20 % of the respondents are females. Age distribution indicates that persons of young to

Table 1
Variable summary – Binary Logit model.

Variables	Percentage/Average (S.D.)
Prefer a specific time slot	78.7 %
Prefer any time slot	21.3 %
Male	80.2 %
Female	19.7 %
Age $\leq$ 24 years	16.3 %
Age 25–60 years	75.7 %
Age > 60 years	8.0 %
Annual Household Income (INR)	
<1,00,000	3.8 %
1,00,000 – 2,00,000	10.8 %
2,00,000–5,00,000	33.2 %
>5,00,000	52.2 %
Business Class	3.8 %
Economy Class	96.2 %
Return Back on the Same day	15.0 %
Education Status	
<UG	10.8 %
UG	43.5 %
PG	29.5 %
Professional Degree	27.2 %
Trip Purpose	
Work	41.5 %
Recreation	36.9 %
Visiting Friends & Relatives	9.7 %
Leisure	11.3 %
The frequency of Air Travel	
One or more than one day a week	12.1 %
Once or Twice a month	56.8 %
Once in a year	26.6 %
First time flying	4.4 %
'Reduction in air-ticket prices'	16.8 %
'No other option for this route.'	4.2 %
Category I Route*	51.9 %
Category II Route*	11.3 %
Category III Route*	36.8 %
Average Travel Fare (INR)	4787.83(3069.0)
Number of observations	2661

*Definitions are provided in APPENDIX.

retirement age dominate the sample. As expected, middle- to high-income groups hold a reasonable share of air travelers. The traveler composition also indicates that persons having at least a bachelor's degree qualification dominate the sample. Regarding trip purposes, the data shows that work (business & work-related trips) and recreational trips contribute significantly to domestic air travel from Delhi.

Nearly 70 % of the travelers make at least one trip in a month. Approximately 5 % of the travelers opine that they are flying since no other option is available for travel to the destination. Half of the flyers are flying to the destinations that come under the Category I route. The average cost of air tickets reported in the sample is approximately INR 5,000 [1 INR = 0.013 USD]. The questionnaire also elicited travelers' views on several attitudinal questions about the choice of flight for their trip (on a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree"). The scores attached to each item were entered into the models; the items "Air-tickets are easily available" and "No other option for this route" were found to explain variations in time-of-day preferences. A more number of individuals opine that reduction in ticket prices is the reason for their travel at that time. Table 1 shows that work trips followed by recreation constitute major shares of trip demand from New Delhi. 'Leisure' implied those activities individuals conduct during free time to pursue their passion/hobbies, while recreation involved those related to enjoyment but not related to hobbies.

Table 2 presents the parameter estimates of a binary logit model calibrated to classify the travelers who prefer only a specific time slot from those who prefer any slot. The dependent variable is '*prefer only a specific time slot.*' The coefficient on the age of individuals suggests that younger individuals prefer a specific slot for traveling. More youthful individuals may have tighter academic and work schedules, which

Table 2
Binary logit model for specific time-of-day preferences.

Variables	Estimate	*t* – Statistic
Constant	**−2.340**	**−6.07**
Age < 24 years	**0.544**	**3.57**
Annual Household Income	**−0.375**	**−5.58**
Travel fare/1000 (INR)	0.023	1.28
Class of Journey (Business)	0.371	1.47
Education < UG Degree	−0.293	−1.76
Trip Purpose = Recreation	**−0.201**	**−2.03**
'Reduction in air-ticket prices'	**−0.257**	**−2.02**
'No other option for this route.'	**0.806**	**2.46**
Holds professional degree	0.171	1.52
Category I Route	**−0.305**	**−2.86**
Category II Route	**−0.442**	**−2.74**
Null log-likelihood	−1844.465	
Adjusted rho-square	0.269	
Number of observations	2661	

Bold-faced estimates are significant at 5% level.

would lead to choosing a particular time of departure, ceteris paribus. The effect of income implies that high-income group individuals show less preference for a specific departure time for traveling. High-income individuals would have the purchasing power parity to purchase tickets and make trips at any time. Therefore, the negative correlation is behaviourally plausible. The variable travel fare is introduced as an indicator for an individual's 'purchasing power,' and the coefficient estimate is as per intuition and self-explanatory. The coefficient for education shows that those with a bachelor's degree or above prefer a specific departure time, reflecting their busy schedules. Such individuals may not have busy academic and work schedules, leading to less preference for a particular time of departure. An interesting and intuitive result is the effect of trip purpose on time-of-day choice – recreation trip makers prefer any slot for trip making. Recreational trip makers could have fewer constraints in a day than those traveling for work/education.

Those who opine that 'Reduction in air-ticket prices' is their major reason for air travel are less likely to prefer a specific departure time window. This correlation might suggest that those who view cost aspects as important are more flexible to travel at any slot, all else being equal. Whereas those who agree with the statement 'No other option for this route' appears to fly during a specific slot. This correlation implies that those without other options, accept to travel during the available time slot The lack of other mode options limits an individual's travel opportunities; therefore, such individuals make choices related to flight availability and make travel during a specific slot. Compared to the individuals flying to destinations under Category III routes, those who fly to both Category I and II cities are less inclined to make trips in a specific slot. Category I and II routes, connecting major cities with New Delhi, have frequent flights and provide passengers with more flight options. Hence, the correlation is behaviourally valid.

4.2. Multinomial Logit model estimation results

This section discusses the estimation results of a Multinomial Logit model (e.g., Busquets et al., 2018 for applications to air itinerary choice) to describe the time of day preferences of individuals who responded that they prefer only a specific time slot (Morning, Mid-day, or Evening) for trip making. Table 3 shows the numerical summary of the variables considered for the model.

The summary shows a general preference for later periods of the day for trip making. The distribution of individuals concerning gender and age closely follows those in Table 1. A slight deviation in the distribution is seen in the context of trip purpose. While work trips hold a significant share in the whole sample (Table 1), recreational trips constitute a significant portion of trips in the sub-sample used here. The distribution of travelers based on category routes (I to III) is nearly the same in both samples (Tables 1 & 3).

Table 3
Variable summary –Multinomial Logit model.

Variables	Percentage/Average (S.D.)
Morning	21.8 %
Mid-Day	47.0 %
Evening	31.3 %
Male	80.1 %
Female	19.9 %
Age ≤ 24 years	17.6 %
Age 25–60 years	75.0 %
Age > 60 years	7.4 %
Education Status	
< UG	10.8 %
UG	44.2 %
PG	28.8 %
Professional Degree	27.5 %
Annual Household Income (INR)	
<1,00,000	4.3 %
1,00,000 – 2,00,000	12.2 %
2,00,000–5,00,000	33.3 %
>5,00,000	50.2 %
Business Class	3.5 %
Economy Class	96.5 %
Return Back on the Same day	14.8 %
'Reduction in air-ticket prices'	16.7 %
'No other option for this route.'	5.2 %
Trip Purpose	
Recreation	35.6 %
Work	42.0 %
Visiting Friends & Relatives	9.9 %
Leisure	11.9 %
Category I Route	50.1 %
Category II Route	9.6 %
Category III Route	40.3 %
Average Travel Fare (INR)	4822.77(3136.44)
Number of observations	2096

The Multinomial Logit model is presented in Table 4. The gender of an individual appears to be a relevant variable in the model. The coefficient suggests that males are less likely to travel during Mid-day and Evening periods. The effect of the variable is more pronounced in the case of the mid-day slot.

Those who hold a professional degree are less inclined to travel during the Mid-day period but prefer the Evening slot, as implied by the model. This correlation might be an implication of their work profile professional degree holders (e.g., Engineers) who have daily constraints that differ from, say, an office clerk. Ticket cost, an indicator of purchasing power, shows a negative influence on the Evening slot. Individuals traveling to destinations falling under the Category I route prefer Mid-day and Evening slots for flying, all else being equal. Category I route connects mega cities in India with New Delhi and being a busy route, passengers could be avoiding morning peak periods, all else being equal. Trip purposes appear to be a relevant variable explaining

Table 4
Multinomial Logit model results*.

Variables	Morning	Mid-Day	Evening
Constant	*Base*	1.810(4.78)	0.488(0.94)
Male		**−0.595(-3.83)**	−0.265(-1.56)
Age 25–60 years		−0.133(-1.29)	
Holds Professional Degree		**−0.317(-2.47)**	0.158(1.17)
Annual Household Income			**0.155(2.56)**
Travel fare/1000 (INR)			**−0.065(-2.64)**
Business Class		0.516(1.49)	0.452(1.15)
'Reduction in air-ticket prices'		−0.265(-1.75)	−0.178(-1.17)
Category I Route		**0.379(3.28)**	**0.394(3.13)**
Trip purpose = Leisure			**0.397(3.85)**
Trip purpose = Recreation			−0.243(-1.46)
Null log-likelihood	−2302.691		
Adjusted rho-square	0.060		
Number of observations	2096		

t-Statistic in Parenthesis; Boldly faced estimates are significant at 5% level.

the slot preferences of individuals. Those who travel for leisure activities prefer the Evening slot, whereas those who travel for recreational activities are less inclined to travel during the evening. Recreational trips could involve visits to destinations that need the visitors to arrive at specified timings. Therefore, a negative correlation is expected.

4.3. Implications of research findings

The study findings are relevant for airline service scheduling and airport operations when correlated with travel demand. For example, young individuals (age < 24) prefer to fly during a particular period (Table 2). When the nation is set to become 'young' (State of the Urban Youth, India, 2012; State of World Population, 2014), this finding is relevant for both airline operators and airport authorities. Broadly, this relationship suggests that younger individuals would not be flexible enough to choose several slots for flying. Hence, this group's trip demand might not be shifted to different slots, ceteris paribus. This finding has implications for airport operations and flight schedules, especially for policies relating to spread demand across different time windows in a day. For example, a scheme that provides additional baggage allowance to youngsters, but during a specific duration in a day to manage air travel demand, could be considered to utilize aviation infrastructure efficiently. Table 2 also indicates that recreational trip makers generally do not prefer a specific slot, as implied by the model. This finding is crucial for service providers since it helps them plan service schedules, mainly to recreational destinations. Since recreational trip demand is generally flexible, ticketing schemes and policies could be designed to utilize the recreational trip demand to ensure passenger loads across different periods. Recreation destination-specific schedules could also be proposed for efficient utilization of airline infrastructure. An interesting observation from Table 4 is that those who fly to Category I destinations prefer later periods of the day. Since the Category I route connects Delhi with megacities such as Mumbai, Chennai, etc., we may expect reasonable trip demand during Mid-day and Evening slots as implied by the model, and operators may devise effective strategies to have adequate infrastructure for managing the demand. This finding suggests that with the increase in travel from Delhi to main Indian cities, there is a need to cater to the demand for travel for Mid-day and Evening periods. These findings have infrastructure implications in major Indian airports. The demand concentration during a specific period would lead to the underutilization of infrastructure facilities during other times. Since travel between major cities could be highly inflexible, mostly due to the business trips, the model effects imply infrastructure upgrades. Table 4 also shows the relevance of gender in air travel choices; that is, males have less preference for Mid-day and Evening slots for trip making. This finding implies that the gender composition of travelers is also relevant for airline schedules and airport management. In the Indian setting, with increased male workforce participation, the finding suggests that travel due to males concentrates on specific times of the day and the requirement of female-specific policies to address their travel requirements.

5. Summary and conclusions

This article explores the preferred time slots of travelers flying from New Delhi to other major cities in India utilizing a revealed preference data collected in 2007. Initially, the paper models the preferences for any time window against a specific slot choice (one among Morning, Mid-day, or Evening periods). Subsequently, the reason for the choice of

a particular period is explored for those who stated that they prefer to make trips during Morning, Mid-day, or Evening periods. Important findings of the study are:

 i. Individuals younger than 24 years are more likely to prefer a specific slot for flying from New Delhi.
 ii. Those who fly for recreational activities have more flexible schedules and show less inclination for a specific slot for flying.
 iii. Individuals who fly to Category I cities and those who make leisure trips are more likely to fly in the evening.

Overall, the study shows that socio-demographic and trip contexts influence air travelers' time of day preferences. An important revelation of the study is that route category affects departure time preferences. Individuals traveling to the major metropolitan cities from New Delhi are observed to prefer a specific departure time, particularly morning slots. It is expected that most business and official travel concentrate between the national capital and other cities. The correlation implied by the study points to the infrastructure needs to manage the demand, which is expected to be 'rigid' temporally. The study also shows that recreational trip makers prefer to make trips during any period, indicating the impacts of travel purpose on air travel demand and the opportunities for devising policies to ensure reasonable load factor in carries across different times in a day.

The study, however, has a few limitations. The study uses revealed preference data and assumes cross-sectional details such as trip data and socio-demographics as explainers of time of day preferences. The situational context might have influenced the responses to a preferred time of day choices, which could be addressed in future studies. In addition, due to data limitations, the models could only provide a limited view of the impacts of age respondents on time-of-day decisions. Potential linear/non-linear effects have been masked due to variable truncation. Similarly, the time-of-day choice alternatives are broad, and that may have confounded several service attributes impacting travel decisions. Advanced choice models such as Nested and Cross-nested models could also be considered to explain the time of day preferences.

CRediT authorship contribution statement

M. Manoj: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review and editing. **K. Ramachandra Rao:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review and editing. **Arvind M. Jain:** Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Category I routes connect New Delhi with other major metropolitan cities in India. Category II routes link the national capital with the Eastern and North-eastern (hilly) states and Islands of India. Finally, Category III routes connect the rest of the airports in India with New Delhi.

Route Category	Description
Category I Route	From Delhi to –Mumbai, Chennai, Bangalore, Hyderabad, and Kolkata.
Category II Route	From Delhi to- Jammu, Kashmir, Leh, Guwahati, Bagdogra, Agartala, Aizwal, Agatti Island,
Category III Route	From Delhi to - All other routes connected to Delhi (Except Category I and Category II route)

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