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# Implications of air travel shopping for non-aeronautical revenue streams: A cross-national empirical analysis

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ABSTRACT

The COVID-19 pandemic dealt a significantly heavy blow to the already competitive air travel industry. As air travel demand is recovering post-pandemic, both airports and airlines are seeking to establish a steady stream of non-aeronautical/ancillary revenues, especially retail, to aid financial recovery. However, a rigorous analysis of passengers' purchasing behaviour during the whole air travel process has been lacking to date. To investigate this matter, we analyse data from a cross-national survey administered in four multi-airport cities (London in the UK, New York City in the US, Shanghai in China, and Sao Paulo in Brazil) in 2020, asking about the respondent's most recent air trip before the pandemic. A Multiple Discrete-Continuous Extreme Value (MDCEV) model was estimated to jointly analyse the discrete decision (to purchase or not) and continuous aspect (of how much is spent) during three stages of travel: at the departure airport, in flight, and at the transfer airport (if applicable). Six hypotheses, about the stage of travel, product and service type, passenger attributes, context of travel, and presence of companions are postulated and examined empirically. The results demonstrate how such factors shape shopping decisions during different stages of travel. The modelling results point towards the need for better pre-flight product information and more tailored offers. Airport retail requires more flexibility in terms of locations, operating hours and channels (in-store, deliveries) to improve shopping convenience. Use of digital tools and passenger data can aid in realising retail revenue improvement. Proposed future research directions include a focus on the transfer airport (where most spending is observed), post-pandemic behaviour changes, the role of product and service attributes, use of non-survey data and environmental impacts of the evolution in air travel retail.

## 1. Introduction

### 1.1. Background

In the fiercely competitive air travel market, airports and airlines have always balanced between competition and cooperation, seeking to maximise their own profits while at the same time being indispensable to each other. Airports benefit from aeronautical revenue which arises directly from charging airlines for the operation of aircraft and the processing of passengers and freight (Graham, 2023), while airlines are under pressure to find ways to manage their costs charged by airports (Chen et al., 2020). On the other hand, both airports and airlines stand to achieve better financial performance through their non-aeronautical and ancillary revenue streams respectively, which in both cases includes profits from retail activities.

The business model of airports started to transform to focus more on non-aeronautical revenue sources around the mid-1990s (Kramer, 2010), resulting in an increase in the share of non-aeronautical revenue as a proportion of total revenue (Oum et al., 2006). Although the revenue structure varies across continents, countries, and even cities, the non-aeronautical revenue has increased to account for almost half of all airport revenues on average (Graham, 2009). Among all types of non-aeronautical revenues (including retail concession, property and real estate, car parking, advertising) in 2019, retail concessions had the largest share, amounting to ca. 30.2% of all non-aeronautical revenue (ACI, 2019). Thus, to achieve more profits, airports are more likely to benefit from efforts into driving non-aeronautical revenue growth, especially through commercial activities in terminals (Graham, 2023; Chen et al., 2020).

With regards to airlines, ancillary revenue (onboard sales of food and

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beverages, duty-free and consumer products, early boarding benefits, frequent flyer program features) (IdeaWorksCompany, 2022), as analogous to non-aeronautical revenues for airports (Kositsky and Trethewey, 2019), forms a significant factor in their business. The International Air Transport Association (IATA) reported an overall $838 billion industry revenue (IATA, 2019), with almost $110 billion in revenue coming from ancillary revenue sources (IdeaWorksCompany, 2021). Research also indicates a positive correlation between high share of ancillary revenue and high operating profits, which suggests airlines should consider placing greater focus on upselling and cross-selling air and non-air ancillary products to improve their profit margins (Warnock-Smith et al., 2017). In addition, with the development of low-cost carriers who drive air travel costs down by offering low ticket fares, traditional airlines have had to fundamentally restructure their operation strategies to protect their interests in light of the fierce competition (Njegovan, 2006). Many existing full-service airlines have followed the practice of low-cost airlines of onboard sales and charging for supplementary services, to pursue growth in ancillary revenues (Babić et al., 2019). In 2018, ancillary revenues accounted for 29% of all revenues for Air Asia, Lufthansa earned an average of $18.47 per passenger in ancillary revenues, and American Airlines generated $7.2 billion from ancillary sources (IdeaWorksCompany, 2019).

However, the revenue implications of the COVID-19 pandemic have been unprecedented, with airports seeing a 60% decline in global passenger traffic volumes in 2020, 49% in 2021, and 24%–27% in 2022 compared to the 2019 level (ICAO, 2022); while 2023 saw a near complete (~95%) return to pre-pandemic levels.[1] The same report points out that at the same time, airlines lost 2703 million passengers and approximately $372 billion of gross passenger operating revenues in 2020, 2201 million passengers and approximately $324 billion in revenues in 2021, and 1109 to 1228 million passengers and approximately $153 to $169 billion in revenues in 2022 compared to the 2019 level. Unsurprisingly, the interest in business recovery emphasises the urgent need for research looking at the realisation of non-aeronautical/ancillary revenue opportunities.

It has been previously reported that there exists a positive association between overall passenger satisfaction and non-aeronautical revenue. On average, when satisfaction increases by 1%, non-aeronautical revenue increases by 1.5% (ACI, 2018). Although no research was found to illustrate the link between passenger experience and ancillary revenues, the onboard retail market is included in the ancillary revenues and around 60% of retail executives report that personalised customer experience is the most significant shopping factor (Timetrade, 2013). Thus, understanding passengers' air travel purchase behaviour, tailoring products to suit their individual preferences and trip context, and prioritizing customer service can result in a positive impact on non-aeronautical/ancillary revenue. Beyond the revenue implications, shopping as an activity can impact the overall air travel experience. Lastly, understanding the factors that drive shopping during air travel contributes to the emerging considerations of the impact of participating in activities on the overall travel experience (Pawlak, 2020; Altın and Zafeirakopoulos, 2020).

### 1.2. Aim and objectives of this paper

Although extensive research has been carried out on non-aeronautical/ancillary revenue for airports and airlines, most research focused on purchase behaviour at the airport whilst largely neglecting purchase preferences during flights or interactions between the two. Moreover, the focus has so far been on whether to 'purchase or not', while the question of 'how much was spent' has not been explored as much, especially considering individual passenger factors (context of travel, sociodemographic attributes, accompanying travellers). Moreover, most research has been limited to airports in a single city or a single country, and the nature of global air travel purchase behaviour has not been researched to date.

Consequently, this study aims to contribute towards addressing the aforementioned research gaps. Specifically, the analysis presented in this paper uses a 2020 online survey administered in four multi-airport cities in different countries (London in the UK, New York City in the US, Shanghai in China, and Sao Paulo in Brazil) to shed light on what drives air travel shopping behaviour in terms of levels of expenditure at different stages of air travel, i.e. at departure airports, during flights, and at transfer airports. To do so, the study makes use of the multiple discrete-continuous extreme value (MDCEV) model that offers an efficient method for jointly capturing the effects of multivariate factors such as trip context, traveller characteristics or product and service types, on how people choose to allocate their shopping budget across different stages of air travel. Given the importance of non-aeronautical/ancillary revenue, the results of the analysis can be valuable in informing comprehensive retail and marketing strategies for airports and airlines that span the entire journey made by the customer.

### 1.3. Outline of the paper

The rest of this paper is organised as follows. Section 2 presents the overall conceptual approach to the problem, drawing upon existing studies on passenger purchase behaviour in the retail market (especially in the air travel industry), including the postulated hypotheses derived from the existing knowledge. Section 3 presents the methodology, including the outline of the data collection process, the main features of the dataset, and the MDCEV modelling framework. Section 4 discusses the results. Section 5 concludes this paper.

## 2. Drivers of shopping decisions

### 2.1. Types of products and services and the context

In terms of airport retail, Herring segmented it into five major categories: duty-free products, food and beverages, news and gifts, specialty retail, and general services (Herring, 2002). The onboard retail market includes a la carte features (onboard sales of food and beverages, checking of baggage and excess baggage, assigned seats or better seats within the same cabin, priority check-in and screening, early boarding benefits, onboard entertainment systems, wireless internet access, etc.), commission-based products (duty-free and consumer products and the sale of hotel accommodations, car rentals and travel insurance), and frequent flyer program features (the sale of miles or points to program partners such as hotel chains and car rental companies, co-branded credit cards, online malls, retailers, and communication services) (IdeaWorksCompany, 2022).

In the context of airports, Castillo et al. found that passengers show a greater propensity to purchase and would spend more money in hub airport malls other than in regional airports (Castillo-Manzano et al., 2018). Fuerst et al. noted that passengers travelling in richer countries tend to spend more (Fuerst et al., 2011).

For in-flight purchases, a global study found that the most desired ancillary services were preferred seating/extra legroom and onboard food and beverages, followed by in-flight Wi-fi and fast-track security screening. However, the popularity for each region varied a lot, with North Americans choosing preferred seating/extra legroom while disliking onboard food and beverages, Europeans choosing preferred seating/extra legroom followed by cabin class upgrade, Latin Americans opting for onboard Wi-fi, and Asia Pacific travellers selecting extra checked baggage/luggage and onboard food and beverages. For travellers from Africa and the Middle East, onboard food and beverages, and fast-track security screening respectively topped their preferences

[1] IATA press release: https://www.iata.org/en/pressroom/2024-releases/2024-01-31-02/#:~:text=Globally%2C%20full%20year%202023%20traffic,the%20end%20of%20the%20year.

(Sabre, 2016). The discussion above suggests the following hypothesis:

**H1**. There is a systematic difference between purchase behaviour in different geographical contexts, which combines differences in airports, existing airline services and high-level customer preferences.

### 2.2. Stage of travel

Consumers often feel good when they make impulse purchase decisions, while an 'after shock' (a latent or delayed concern of regret after an impulse purchase) would encounter them afterward (Crawford and Melewar, 2003). However, unlike traditional shopping methods, due to the nature of airport retail, passengers may encounter 'after shock' when they are already on the flight and unable to reverse the decision and ask for a refund. Moreover, the airport is considered an attractive retail location, as passengers are forced to stay in the terminal until their flights are called and airport shopping becomes one of their few options to spend time. Airports Council International-North America indicated that airport shops can generate annual sales of $800–1200 per square foot (Airports Council International—North America, 2015). The average regional mall, by comparison, produces around $300 per square foot (Creative Host Services, 2004). There are even claims that airports are gradually becoming shopping malls with attached runways (Livingstone, 2014; Volkova, 2009).

Thomas revealed that stress level and excitement are two emotions that influence buying habits (Thomas, 1997). Less stress and more excitement would result in a greater propensity to purchase. Thus, the 'happy hour', after passengers have their boarding pass in hand, is an easier period to 'manipulate' buying behaviours, as passengers feel less stressed and more excited. Newman and Lloyd Jones pointed out that the check-in area is the most important place for advertisers because passengers are in the most relaxed part of their travel and are more willing to shop (Newman and Lloyd-Jones, 1999). Chen et al. also indicated that when deciding the shop locations, more profitable shops should be placed near the entrance area (Chen et al., 2019). In addition, several studies indicated that passengers are more likely to purchase at airports with more open space and less congestion and queuing, while congestion discourages sales (Fuerst et al., 2011; Bowes, 1999; Fasone et al., 2016). Van et al. also found that airports with curved hallways, curvilinear roofs, good greenery, light-coloured materials for the floor, and warm atmospheric lighting had better retail revenue as these features make passengers feel more comfortable (Van Oel and Van den Berkhof, 2013).

Unlike airports, airlines are limited by narrow cabin space and payload restrictions. They need to offer more customised products and services to create a more sustainable retail environment. This drives innovative solutions such as pre-order duty-free shopping delivered to the passenger seat on the return flight (Finnair) or arrival gates (Lufthansa), onboard purchases via in-flight entertainment systems for home delivery (Air China), and ordering meals and duty-free items through various sources (personal devices, tablets provided by the cabin crew, or seatback screens) (China Eastern). The above discussion leads to the following hypothesis:

**H2**. There is a systematic difference between the choice of products and services as well as the amount purchased at the airport and during flight.

### 2.3. Attributes of the shopper

Moving onto attributes of the shopper, Dittmar et al. found that women are more likely to indulge in impulse buying than men, and women prefer items related to symbolic and self-expressive value, while men prefer items related to leisure and instrumental value (Dittmar et al., 1995, 1996). In terms of the airport retail market, conclusions are much the same. Evidence shows that women tend to spend more time on shopping than men and would love to purchase more at the airport than men (Freathy and O'Connell, 2012; Perng et al., 2010). Tseng and Wu indicated that female passengers are more interested in shopping whereas male passengers are more interested in airport entertainment (Tseng and Wu, 2019).

Bashar found that people aged between 18 and 39 are more likely to purchase impulsively (Bashar et al., 2013), which is consistent with the research conducted by Bellenger et al. that impulse buying is more likely in 18–39 year olds and declines thereafter (Bellenger et al., 1978). In the context of the airport retail market, Del et al. indicated that while younger passengers show a greater propensity to purchase at airports, older passengers tend to spend more money (Del Chiappa et al., 2016). Tseng and Wu also found that older passengers are more likely to choose dining activities (Tseng and Wu, 2019).

As for income, Kasarda and Kasarda noted that passengers with an average annual income of $80,130 were the most desirable retail clients (Appold and Kasarda, 2006). Tseng and Wu also showed that higher annual income overseas trip passengers were more likely to choose airport shopping and dining activities than entertainment (Tseng and Wu, 2019). All the above points towards the following hypothesis:

**H3**. Shopping decisions, i.e. selection of product or service type and the amount purchased at airports and during flights are driven at least partly by passenger sociodemographic attributes.

### 2.4. Dwell time, flight duration and time of day

As the time taken for passing through security is unpredictable, passengers tend to arrive at the airport early, resulting in increased waiting time and thus creating conditions for retail activity at the airport. Volkova and Müller found that longer dwell time can boost the consumption of food and beverages in the airport (Volkova and Müller, 2012). Being forced to stay at the airport while waiting for connecting flights, transfer passengers are also found to be more likely to purchase at airport shops and restaurants (Appold and Kasarda, 2006).

Research also found that long-duration flight passengers may be more likely to purchase food and beverages and other goods at the airport (Appold and Kasarda, 2006). In the context of onboard retail, Warnock et al. noted that long-haul flight passengers would love to buy in-flight hot meals while short-haul flight passengers would buy non-alcoholic drinks (Warnock-Smith et al., 2017). Based on these findings in the literature, the following hypothesis is proposed:

**H4**. Amount of time spent at the airport, duration of flight and time of day of travel impact purchase decisions in terms of the product and service types and level of expenditure.

### 2.5. Presence of travel companions

Chung et al. indicated that passengers who travel with companions are more likely to indulge in airport retail (Chung et al., 2013). Furthermore, passengers with children are more likely to purchase, especially food and beverages, at airports. Castillo et al. also found that the interest in food and beverages would be higher with the increase in the number of companions (Castillo-Manzano, 2010). This finding leads to the following hypothesis:

**H5**. The number and character of accompanying travellers impact purchase decisions in terms of the product or service types and level of expenditure.

### 2.6. Domestic vs. international travel

Research has also shown the role of the passenger segment with overseas passengers spending more money than domestic passengers, and leisure travellers spending more than business travellers (Torres et al., 2005; Tovar et al., 2009). In research located at Taiwan Taoyuan Airport, Lin and Chen found that domestic passengers prefer alcohol and

tobacco, while foreigners spend more on souvenirs and packaged foods (Lin and Chen, 2013). Tseng and Wu also found that when having enough dwell time, overseas passengers preferred shopping followed by entertainment and finally dining (Tseng and Wu, 2019). This leads to the following hypothesis

**H6**. The domestic vs. international context of air travel as well as purpose (leisure vs business) and class of travel (economy vs business) impact purchase decisions in terms of the product and service types and level of expenditure.

Overall, we observe that the literature sheds insight into a wide range of potential factors affecting shopping decisions during air travel. The hypotheses listed above are summarised in Fig. 1. The research in this paper presents a comparative study across different geographical contexts, while also accounting for the various factors identified from the literature, in explaining the decision to shop during different stages of air travel and how much is spent in each stage.

## 3. Research method

### 3.1. Survey context and data collection

The data for this study was collected as part of a two-wave cross-national survey undertaken for the research project ACCLAIM (Airport Capacity Consequences Leveraging Aviation Integrated Modelling) aiming at analysing various factors that influence air travellers' itinerary choices (Manca et al., 2023a, 2023b). The survey data was collected from an online questionnaire administered in 2020 to a sample of residents from four different multi-airport cities:

- London (airports included: Heathrow, Gatwick, City, Stansted, Luton, Southend)
- New York (airports included: JFK, Newark Liberty International, La Guardia),
- Shanghai (airports included: Pudong, Hongqiao),
- Sao Paulo (airports included: Guarulhos, Congonhas, Viracopos).

The respondents were recruited with assistance from a market research company Panelbase (www.panelbase.net) and offered monetary incentives for completing the surveys. The survey asked the residents about their most recent air travel journey in 2019, starting from one of the airports in their city. The journeys made before January 2019 or after December 2019 were excluded to avoid potential recall bias or impact of COVID-19 restrictions respectively. The motivation for online administration, as opposed to a more conventional intercept survey approach, stemmed from the original aim of the ACCLAIM study that required design of hypothetical travel scenarios in wave two of the survey, based on real trips reported in wave one. This would have proven infeasible from the practical standpoint given size of the survey, its cross-national scope and the need for an efficient follow-up, in addition to presence of the pandemic restrictions at the time (Manca et al., 2023a, 2023b). More to the point, intercept surveys are typically limited in the level of detail that can gathered due to time constraints, whereas the online survey in ACCLAIM was able to gather a significant amount of detail on the purchasing behaviour of the respondents.

Three main blocks of information available from the original survey have been used in the analysis presented in this paper:

- Trip context, including departure time, duration, trip purpose, class of travel, transfers and presence of companions.
- Respondent socio-demographic attributes, including gender, age, employment, education, marital status, number of household members and household income level.
- Purchasing behaviour, including product and services selected and the total amount of money spent on each product/service category at each stage of travel.

The specific product and service categories that the respondents reported on include:

1) alcohol and tobacco (and associated products);
2) books and magazines;
3) fashion, cosmetics, accessories;
4) foreign currency;
5) food and beverages (non-alcoholic);
6) gifts, souvenirs, children's products, and toys;
7) internet access;
8) alcoholic beverages, tobacco, and associated products;
9) technology and entertainment, e.g., headphones, computer equipment;
10) tickets and transport services, e.g., rail tickets, taxi services;
11) travel essentials, e.g., passport holder, pillow, plug adapter;
12) other.

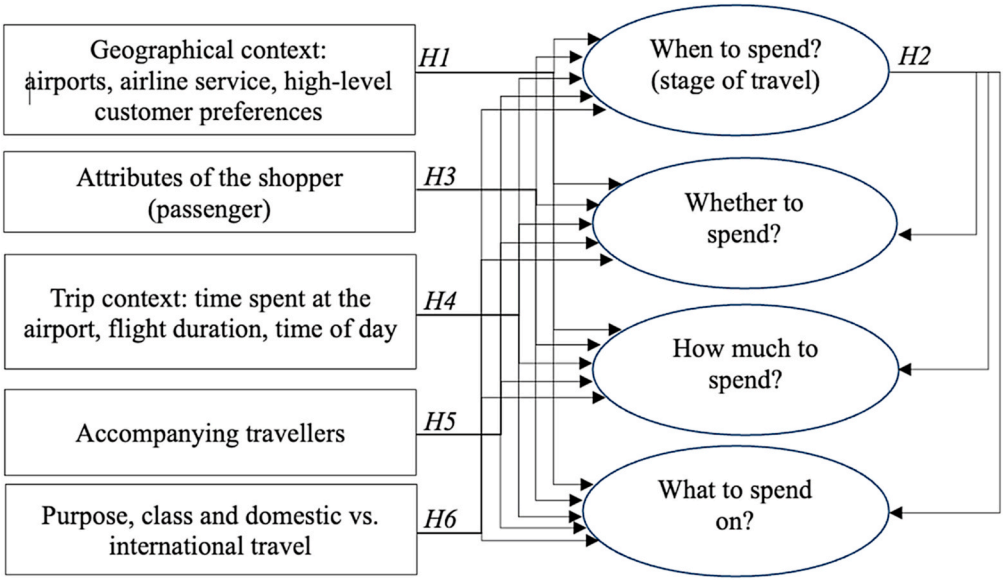



**Fig. 1.** Conceptual mapping of hypotheses tested in the current analysis.

The initial sample comprised 1496 responses. Individuals with inconsistent or incomplete purchase behaviour were removed, e.g., where the respondents indicated purchase but with no information concerning the level of expenditure. Ten respondents who claimed to have taken direct flights but made purchases at the transfer airport were excluded as well, due to the inconsistency. The final sample size after data cleaning was 1343 passengers, with:

- 365 in London, including 157 (43%) respondents flying from Heathrow, 104 (28%) from Gatwick, 23 (6%) from City, 46 (13%) from Stansted, 30 (8%) from Luton and 5 (2%) from Southend;
- 207 in New York, including 101 respondents flying from JFK (49%), 83 (40%) from Newark Liberty International and 23 (11%) from LaGuardia;
- 376 in Shanghai, including 278 (74%) respondents flying from Pudong and 98 (26%) from Hongqiao;
- 395 in Sao Paulo, including 288 (73%) respondents flying from Guarulhos, 104 (26%) from Congonhas and 3 (1%) from Viracopos.

Sample descriptive statistics are reported in Tables 1 and 2. We see that the most common flight departure time is during the daytime (9am-9pm). Flights of length up to 6 h and for non-business reasons form the majority of the sample, primarily in the economy class. More than 80% of the responses include flights with no transfers (which points towards the reduced ability to consider purchasing behaviour at transfer airports in our analysis). Most respondents indicated they were travelling either individually or with family members between 16 and 65 years old. There was a relatively even share of male and female respondents across the cities. As for the age distribution, Shanghai and Sao Paulo respondents tended to be younger on average compared to London and New York. The overall representativeness of the sample was investigated in the previous study using the ACCLAIM dataset (Manca et al., 2023b), comparing distributions of business and non-business trips, international and domestic travel, gender and income of the travellers to a number of sources available from the respective countries. The conclusion was that whilst deviations from the officially published statistics could be observed, relative sizes of various segments (as defined by the aforementioned variables) were preserved.

As for the purchasing behaviour, Table 2 indicates that between half and up to two-thirds of the respondents, depending on the city, would choose to shop at the departure airport. This is about twice as likely as making a purchase during the flight. As for the passengers whose travel involved transfers, whilst the total number of respondents is relatively low, of those transferring about half (for respondents originating in London and Sao Paulo) and up to 75–80% (for respondents originating in Shanghai and New York) reported making a purchase during the transfer. In terms of the level of expenditure, the pattern varies across the countries. Overall, the highest level of expenditure was reported by respondents travelling from Shanghai (around 120 to 130 USD), followed by London and Sao Paulo (similar levels, between 50 and 110 USD) and New York (35–55 USD).

### 3.2. Modelling methodology: MDCEV model

Our intention to analyse the (discrete) decision to purchase at each stage alongside how much was spent (continuous) motivated the use of a multiple discrete-continuous extreme value (MDCEV) model (Bhat, 2008), which has wide-ranging applications in transport and marketing research (Bhat and Sen, 2006; Calastri et al., 2021). Its growing popularity stems from the ability to efficiently handle multiple discrete alternatives, i.e. avoiding a combinatorial explosion of the number of alternatives, while accommodating behavioural considerations (decisions based on utility, diminishing marginal returns) and the inclusion of total resource (budget) constraints, without loss of mathematical tractability facilitating model estimation.

The MDCEV framework has been previously applied in contexts related to air travel expenditure (Pellegrini et al., 2019) or time allocation to activities by airport terminal visitors (Chung and Lu, 2020), but not to model shopping behaviour in the context of air travel. In the original formulation, the model is expressed as a utility-maximisation problem in which an individual can choose to consume amounts of goods from (or alternatively, spend money on) $K$ discrete alternatives based on their relative utilities, as follows (Eqs. (1)–(3)):

$$\underset{x_k \forall k}{\text{Max}} \quad \sum_{k=1}^{K} \frac{\gamma_k}{\alpha_k} \psi_k \left( \left( \frac{x_k}{\gamma_k} + 1 \right)^{\alpha_k} - 1 \right) \qquad \text{Eq. 1}$$

$$\text{subject to } \sum_{k=1}^{K} x_k p_k = B \qquad \text{Eq. 2}$$

$$\psi_k = \exp(V_k + \varepsilon_k) \qquad \text{Eq. 3}$$

where $K$ is the number of discrete alternatives, $x_k$ is the consumption level (or money allocation), and $p_k$ is the unit price of alternative $k$. The model also incorporates the notion of the outside good, i.e. an aggregate measure of the consumption of all products that are not of interest for the study. Thus, each respondent can choose from up to 3 discrete alternatives (to purchase at the departure airport, during flight and/or during the transit if applicable) plus the outside good alternative. The total expenditure on the shopping as well as the outside good needs to add up to the assumed disposable budget $B$ available to the respondent. In simple terms, the decision-makers seek to allocate their available income between expenditure during the different stages of travel and a large outside good (all other expenditures) to maximise their utility. Note that the price $p_k$ collapses to 1, since expenditure at each stage of travel in each country is expressed in the same terms, i.e. converted from the reported currencies to US dollars (USD) and accounting for the Purchasing Power Parity, or PPP (cf. Table 2).

To make the model operational, the term $\varepsilon_k$ is assumed to be independently and identically distributed following the Gumbel distribution with scale parameter $\sigma$. $\alpha_k$ and $\gamma_k$ are parameters determining satiation. In addition, $\gamma_k$ serves to admit the possibility of corner solutions, i.e., passengers buying nothing during the whole air travel episode. Finally, $V_k$ determines the base utility for each alternative, with outside good $V_{outside}$ being fixed to 0 as the reference. Such assumptions provide a means of deriving the probability of an observed vector of consumptions when an outside good is included among the alternatives, and is shown as follow (Eqs. (4)–(6)):

$$P(x_1^*, x_2^*, \ldots, x_M^*, 0, \ldots, 0) = \frac{1}{\sigma^{M-1}} \left( \prod_{m=1}^{M} f_m \right) \left( \sum_{m=1}^{M} \frac{p_m}{f_m} \right) \left( \frac{\prod_{m=1}^{M} e^{\frac{V_i}{\sigma}}}{\left( \sum_{k=1}^{K} e^{\frac{W_k}{\sigma}} \right)^M} \right) (M-1)! \qquad \text{Eq. 4}$$

$$\text{where } f_m = \frac{1 - \alpha_m}{x_m^* + \gamma_m} \qquad \text{Eq.5}$$

$$W_k = V_k + (\alpha_k - 1) \log \left( \frac{x_k^*}{\gamma_k} + 1 \right) - \log(p_k) \qquad \text{Eq.6}$$

and $\sigma$ is a scale parameter, $x_k^*$ is the observed (optimum) consumption of $k$ and $M$ indicates possible combinations of discrete alternatives with positive money allocation (expenditure).

To obtain an estimate of the disposable budget, the mid-point of the annual household income level was regarded as the disposable household income for the respondent. Subsequently, the square root scale (OECD, 2008) was introduced to convert household income into adjusted disposable income per equivalent household member, which could be formulated as (Eq. (7)):

$$DI_{ij} = Y_i \Big/ \sqrt{S_i} \qquad \text{Eq.7}$$

where

**Table 1**
Sample descriptive statistics: trip context and socio-demographic composition.

| | | London (n = 365) | New York (n = 207) | Shanghai (n = 376) | Sao Paulo (n = 395) | Overall (n = 1343) |
|---|---|---|---|---|---|---|
| Departure time | Morning (06:15–09:00) | 26% | 34% | 19% | 24% | 25% |
| | Daytime (09:15–21:00) | 59% | 57% | 71% | 56% | 61% |
| | Evening (21:15–24:00) | 5% | 5% | 2% | 12% | 6% |
| | Night (00:15–06:00) | 10% | 4% | 8% | 8% | 8% |
| Duration | Short (up to 6h) | 59% | 53% | 68% | 67% | 63% |
| | Medium (6h–12h) | 25% | 35% | 17% | 15% | 21% |
| | Long (above 12h) | 16% | 12% | 15% | 18% | 16% |
| Travel purpose | Business | 18% | 13% | 29% | 21% | 21% |
| | Other reasons | 82% | 87% | 71% | 79% | 79% |
| Class of travel | Economy | 79% | 67% | 72% | 88% | 78% |
| | Premium economy | 13% | 16% | 11% | 6% | 11% |
| | Business class | 6% | 9% | 14% | 5% | 9% |
| | First-class | 2% | 8% | 3% | 1% | 2% |
| Transfer | None | 86% | 83% | 91% | 81% | 85% |
| | One or more | 14% | 17% | 9% | 19% | 15% |
| Companions (multiple allowed) | Alone | 42% | 43% | 50% | 38% | 43% |
| | With child (under 15) | 13% | 12% | 13% | 13% | 13% |
| | With family member (16–65) | 38% | 39% | 30% | 39% | 36% |
| | With family member (65+) | 7% | 12% | 1% | 7% | 6% |
| | With friends or colleagues | 16% | 17% | 24% | 26% | 21% |
| Gender | Male | 50% | 38% | 53% | 51% | 49% |
| | Female | 50% | 62% | 47% | 49% | 51% |
| Age | 18–34 | 28% | 21% | 56% | 40% | 38% |
| | 35–59 | 58% | 50% | 44% | 51% | 51% |
| | 60+ | 16% | 29% | 0% | 9% | 11% |
| Annual household income level | Level 1[a] | 3% | 3% | 0% | 1% | – |
| | Level 2[a] | 3% | 3% | 3% | 1% | – |
| | Level 3[a] | 8% | 16% | 42% | 27% | – |
| | Level 4[a] | 32% | 41% | 38% | 30% | – |
| | Level 5[a] | 36% | 19% | 15% | 25% | – |
| | Level 6[a] | 9% | 18% | 2% | 6% | – |
| | Prefer not to answer | 9% | <0% | 0% | 10% | – |

| [a]Income Levels: | *London* | *New York* | *Shanghai* | *Sao Paulo* |
|---|---|---|---|---|
| *Level 1* | *<10k GBP* | *<10k USD* | *<50k RMB* | *<3k BRL* |
| *Level 2* | *10k-15k GBP* | *10k-25k USD* | *50k-100k RMB* | *3k-12k BRL* |
| *Level 3* | *15k-25k GBP* | *25k-50k USD* | *100k-300k RMB* | *12k-60k BRL* |
| *Level 4* | *25k-50k GBP* | *50k-100k USD* | *300k-500k RMB* | *60k-120k BRL* |
| *Level 5* | *50k-100k GBP* | *100k-150k USD* | *500k*-1M RMB | *120k-300k BRL* |
| *Level 6* | *>100k GBP* | *>150k USD* | >1M RMB | *>300k BRL* |

$Y_i$ denotes the annual household income of household *i*,

$DI_{ij}$ is the adjusted disposable income of each member j of household i,

$S_i$ is the number of members in household *i*.

As shown in Table 1, the London and Sao Paulo datasets contain several respondents who preferred not to answer the income question. The respective average adjusted disposable income was imputed in such cases to avoid sample reduction at the minor and acceptable (due to relatively low rate of missingness) risk of affecting the satiation parameters. In order to turn the disposable income into expenditure budget, data from the Circular Economy Innovation Communities (CEIC) was used for London, New York, and Shanghai (CEIC.(2022)., 2022) whilst Instituto Brasileiro de Geografia e Estatistica (IBGE) provided the data for Sao Paulo (IBGE.(2022)., 2022). Thus, the ratios were: 0.53 for London, 0.67 for New York, 0.63 for Shanghai, and 0.77 for Sao Paulo.

Following the structure and assumptions above, the model was estimated using the Apollo package (Hess and Palma, 2019) in R software (R Core Team. R: A Language and Environment for Statistical Computing, 1986). The 'alpha-gamma' profile was chosen to analyse the model, where a generic $\alpha$ coefficient and alternative-specific $\gamma_k$ coefficients were used, to ensure identifiability of the model. The specification search used likelihood ratio tests to verify whether inclusion of a variable improves the overall fit, in addition to inspecting interpretability and statistical significance (Wald tests) of the parameters, assuming 95% cut-off threshold to limit model complexity. Finally, at each step, the model was inspected for successful estimation convergence, i.e. absence of anomalously large values of parameter estimates or standard errors. The standard errors were derived using robust covariance matrices, i.e. so-called sandwich estimators. This guards against general mis-specification of the model or heteroscedasticity (Kauermann and Carroll, 2001) and the consequent bias and errors.

## 4. Results

The results of the model calibration are reported in Table 3, where each coefficient is followed by the robust *t*-statistic (Wald statistic),[2] in line with the typical convention of reporting MDCEV results, e.g. (Calastri et al., 2021). The respondents' socio-demographic attributes, trip-specific characteristics, product or service type interactions

[2] The Wald statistic is used to assess relative sizes of an estimated parameter and its standard error compared to a null hypothesis of that parameter being equal to a specific value, typically 0. In other words, it permits assessment whether the postulated parameter is (statistically) significantly different than zero, given an estimate of its standard error. The statistic is defined as the ratio of the square difference of the estimated and null-hypothesis values to variance of the parameter obtained in the process of maximum likelihood estimate. The square root of the statistic is asymptotically normally distributed for larger samples (and *t*-distributed for smaller samples).

**Table 2**
Descriptive statistics: purchase.

| Origin | Reported stage of travel | Number of respondents making a purchase | Percentage | Average expenditure by those who purchased[b] |
|---|---|---|---|---|
| London | Departure (n = 365) | 236 | 65% | 51 GBP (66 USD) |
| | Flight (n = 365) | 135 | 37% | 38 GBP (49 USD) |
| | Transfer[a] (n = 52) | 28 | 54% | 82 GBP (106 USD) |
| New York | Departure (n = 207) | 122 | 59% | 41 USD (41USD) |
| | Flight (n = 207) | 60 | 29% | 38 USD (38 USD) |
| | Transfer[a] (n = 36) | 27 | 75% | 52 USD (52 USD) |
| Shanghai | Departure (n = 376) | 235 | 63% | 543 RMB (130 USD) |
| | Flight (n = 376) | 169 | 45% | 518 RMB (124 USD) |
| | Transfer[a] (n = 33) | 26 | 79% | 489 RMB (117 USD) |
| Sao Paulo | Departure (n = 395) | 205 | 52% | 158 BRL (66 USD) |
| | Flight (n = 395) | 92 | 23% | 252 BRL (105 USD) |
| | Transfer[a] (n = 73) | 40 | 55% | 223 BRL (93 USD) |

The assumed exchange rates: 0.7755 [GBP/USD] for London, 4.1759 [RMB/USD] for Shanghai, and 2.3996 [BRL/USD] for Sao Paulo.

[a] Passengers departing from the indicated origin but transferring elsewhere.

[b] Conversion to USD using 2019 Purchasing Power Parities (PPP) (The World Bank, 2020).

(products of variables) were tested in the discrete part of the model through $\psi_k$, where the parameters indicate how much these factors are associated with *the decision to purchase* during specific stages of travel. In particular, where the parameter is positive, the given factor (or a product of factors in the case of interactions) is associated with higher chances of engaging in shopping during the respective stage of travel. The included interaction parameters indicate combinations of such factors. The $\gamma_k$, responsible for modelling *how much is spent*, was parameterised in terms of city and trip stage. Here, the higher the value, the less rapid the satiation and hence higher expenditure. During the estimation, we also observed that the value of the generic $\alpha$ parameter approaches 0, which indicates a log-formulation of the utility function, as per Eq. (6). In other words, each additional unit of money spent results in diminishing returns.

At a high level, the model presents a good fit for MDCEV standards, with McFadden's Pseudo-R squared above 0.1 (Bhat and Sen, 2006). This provides an indication that the included factors substantially improve the overall model fit, i.e. play a role in explaining the shopping behaviour. In addition, observing the baseline utility constants at the top of Table 3, which by themselves carry little substantive interpretation (Bhat, 2008), their large negative values (in relation to the outside good, for which the parameter is fixed at 0) signify that purchase during travel comprises only a small portion of the overall disposable budget of the respondents available during this travel episode.

Referring to the first hypothesis (*H1*), we observe differences across the cities in terms of how people chose to spend money during air travel. This is particularly visible when observing the satiation parameters. Whilst in the case of New York respondents, there is a similar propensity to spend money across the different stages of travel (parameters ranging from 3.54 to 4.99), for the other three cities the transfer airport sees the highest propensity for spending by a large margin (satiation parameter values of 15.37 for London and 18.98 for Shanghai), followed by in-flight sales (satiation parameter values of 4.10 for London and 9.37 for Sao Paulo) and the departure airport (satiation parameter values of 3.68 for London and 7.30 for Shanghai). As higher satiation parameters correspond to less rapid satiation and hence higher spending, ceteris paribus, the results are consistent with the average spending level reported earlier in Table 2, with Shanghai respondents reporting the highest spending, followed by Sao Paulo, London and New York. Importantly, the association of the expenditure with the choice of products and services also varies across the four cities, as will be discussed below. Overall, given the statistically significant and explainable parameters discussed above, we conclude by accepting *H1*, i.e. there is a systematic difference in purchasing behaviour across different geographical contexts.

With regards to the second hypothesis (*H2*), we can observe heterogeneity in association with the decision to shop and the selected product and service types across different stages of travel. When it comes to alcohol and tobacco, it is more likely to drive expenditure at the departure airport and during flight (parameter estimates of 1.44 and 1.46 respectively), though less so amongst younger people in the former case (−0.86). Similarly, the expenditure at departure airports and during flight is positively associated with purchase of books and magazines (parameter estimates 0.72 and 0.57), foreign currency (1.61 and 0.81) or internet access (1.54 and 2.34).

The pattern becomes slightly more nuanced for fashion and cosmetic products. In the case of the departure airport, expenditure is driven more by purchase of such products by female customers (parameter estimate of 0.64), especially if not travelling in first-class or for business travel (−2.24 and −1.13 respectively). Expenditure on such products is lower during flight (parameter value of −0.54), unless the traveller is travelling with a child or is single in terms of marital status (parameter estimates of 1.86 and 2.51 respectively).

An even more complex set of patterns can be observed in the case of food and beverages. In particular, purchase of such products is associated with higher expenditure at departure airports and during flight (parameter values of 1.71 and 1.12 respectively). In the case of the departure airport, the association is stronger for passengers travelling between 9pm and midnight (0.57) or for those travelling from New York or Sao Paulo on journeys of length up to 6 h (parameter estimates of 0.78 and 1.33). At the same time, the association is lower amongst business class travellers or those travelling for business purpose (−0.86 and −0.72). As for the flight time, the positive association with expenditure is stronger amongst economy class passengers from London, New York or Sao Paulo (1.04, 1.58 and 1.11) or amongst passengers travelling on flights lasting up to 6 h. In the latter case, the effect varies across the cities as shown by varying parameters for London (0.90), New York (1.46), Shanghai (0.66) and Sao Paulo (1.45).

As for gifts, souvenirs and children's product and toys, these are also more likely to be associated with expenditure at the departure airport and during flight (parameter estimates of 0.94 and 1.63 respectively). However, the association turns the other way around for departure time between 9pm and midnight (−1.67) or amongst travellers with children from London, New York or Shanghai (−4.9, −4.79, −2.82 respectively). Looking at expenditure in relation to departure time, a reversal is observed amongst low-income passengers or those departing between 9pm and midnight (−1.63, −2.00). When it comes to tickets and transport services, these tend to be less likely expenditures during flight (parameter value of −3.31), unless among passengers with higher education or low-income (2.43 and 1.66 respectively). As for travel essentials, these are positively associated with expenditure during flight (parameter estimate of 1.65), though this becomes less pronounced amongst passengers with business trip purpose or of low-income (−1.07 and −1.10 respectively).

Finally, we did not observe any statistically significant relationship for technology and entertainment or for any products and services purchased during the transfer stage. In the former case, this could indicate absence of heterogeneity across stages, i.e. such products and

**Table 3**
MDCEV model results: purchasing behaviour during air travel
*t*-statistics (Wald) reported in the brackets.[a].

| Variable | | Stage of travel | | |
|---|---|---|---|---|
| | | Departure airport | During flight | Transfer airport |
| *Decision to shop or not ($\psi_k$)* | | | | |
| Baseline utility constants[b] | London | −10.41 (69.40) | −11.76 (67.02) | −10.21 (40.72) |
| | New York | −11.20 (63.19) | −12.52 (61.77) | −9.74 (25.74) |
| | Shanghai | −10.82 (61.98) | −11.95 (65.94) | −10.46 (23.51) |
| | Sao Paulo | −11.13 (70.47) | −12.41 (63.89) | −10.35 (42.01) |
| *Travel context and company* | | | | |
| Business trip | | 0.54 (3.75) | . | 1.34 (4.93) |
| Premium economy class | | . | 0.67 (3.53) | . |
| International trip | | . | . | . |
| Departure time: midnight-6am | | . | 0.62 (2.95) | 0.53 (2.02) |
| Trip duration up to 6 h | | −0.56 (4.06) | −0.30 (2.06) | . |
| Travelling with a child or children | | 0.47 (3.18) | 0.37 (2.11) | . |
| *Traveller sociodemographic characteristics* | | | | |
| Age (18–34) | | . | 0.22 (1.97) | . |
| Unemployed | | 0.86 (3.18) | . | . |
| Low-income[c] | | 0.77 (6.73) | 1.00 (7.69) | 1.13 (4.18) |
| High-income[d] | | −0.65 (3.76) | −0.98 (5.14) | . |
| *Product or service (and interactions with other variables)* | | | | |
| Alcohol and tobacco | | 1.44 (7.77) | 1.46 (5.86) | . |
| *Age (18–34) | | −0.68 (2.16) | . | . |
| Books and magazines | | 0.72 (5.29) | 0.57 (2.23) | . |
| Fashion, cosmetics, accessories | | 1.03 (2.75) | −0.54 (1.97) | . |
| *First-class | | −2.25 (3.19) | . | . |
| *Business travel | | −1.13 (2.13) | . | . |
| *Female | | 0.64 (1.98) | . | . |
| *Travelling with a child or children | | . | 1.86 (2.63) | . |
| *Single | | . | 1.68 (2.51) | . |
| Foreign currency | | 1.61 (6.35) | 0.81 (2.46) | . |
| Food and beverages | | 1.71 (9.63) | 1.12 (3.08) | . |
| *Business class | | −0.86 (2.83) | . | . |
| *Economy class | | | | |
| London | | . | 1.04 (2.58) | . |
| New York | | . | 1.58 (4.07) | . |
| Shanghai | | . | . | . |
| Sao Paulo | | . | 1.11 (2.06) | . |
| *Business trip purpose | | −0.72 (3.71) | . | . |
| *Departure time: 9pm-midnight | | 0.57 (3.41) | . | . |
| *Trip duration up to 6 h: | | . | . | . |
| -London | | . | 0.90 (2.06) | . |
| New York | | 0.78 (2.99) | 1.46 (3.26) | . |
| Shanghai | | . | 0.66 (1.96) | . |
| Sao Paulo | | 1.33 (5.88) | 1.45 (3.11) | . |
| Gifts, souvenirs, children's products, toys | | 0.94 (4.29) | 1.63 (3.87) | . |
| *Low-income[c] | | . | −1.63 (2.60) | . |
| *Departure time: 9pm-midnight | | −1.67 (3.68) | −2.00 (3.42) | . |
| *Travelling with a child or children: | | . | . | . |
| London | | −4.90 (3.77) | . | . |
| New York | | −4.79 (3.85) | . | . |
| Shanghai | | −2.82 (2.59) | . | . |
| -Sao Paulo | | . | . | . |
| Internet access | | 1.54 (11.09) | 2.34 (13.18) | . |
| Technology and entertainment | | . | . | . |
| Tickets and transport services | | . | −3.31 (3.36) | . |
| *Higher education | | . | 2.43 (2.79) | . |
| *Low-income[c] | | . | 1.66 (2.46) | . |
| Travel essentials | | . | 1.65 (3.90) | . |
| *Business trip | | . | −1.07 (2.38) | . |
| *Low-income[c] | | . | −1.10 (1.97) | . |
| ***Level of expense in each stage of travel ($\gamma_k$)*** | | | | |
| Satiation parameters | London | 3.68 (8.98) | 4.10 (6.99) | 15.37 (2.83) |
| | New York | 3.54 (7.42) | 4.07 (5.66) | 4.99 (2.59) |
| | Shanghai | 7.30 (8.49) | 8.17 (7.32) | 18.98 (2.64) |
| | Sao Paulo | 4.84 (8.64) | 9.37 (5.17) | 18.38 (3.63) |
| ***Goodness-of-fit*** | | | | |
| Log-likelihood (constants only): −9052.38 | | | | |
| LL (final): −8138.76 | | | | |
| McFadden's Pseudo R-squared: 0.101 | | | | |

[d] No statistically significant relationship observed.

[a] Since square root of Wald's statistic is approximately normally distributed for larger samples, the critical value of such statistic is 1.96 at 95% level of confidence (two-tailed).
[b] The reference is 'the outside good' for which the parameter is fixed at 0, to ensure identifiability.
[c] Low income is the respondents whose annual household income level is 1, 2 or 3.
[d] High income is the respondents whose annual household income level is 6.

services are equally likely to be purchased during any of the stages of travel. In the case of transfer airports, absence of any statistically significant relationship may indicate that any of the products and services are equally associated with purchases made during the transfer. However, we also note the relatively small number of observations with a transfer (cf. Table 2), suggesting that there could be insufficient data to capture such relationships and elevated risk of type 2 error.

Overall, we partially accept *H2*. On the one hand, there is evidence for claiming the existence of systematic difference between choice of products and services that are behind the expenditure at departure airports and during flights. On the other, there is no sufficient evidence for its acceptance in the context of transfer airports.

Our third hypothesis (*H3*) postulated the role of sociodemographic attributes. In addition to the effects mentioned above in the context of specific products and services, it is possible to observe that younger people (age less than 35) displayed a higher probability of purchasing onboard the flight compared with passengers aged over 35 (parameter estimate of 0.22). As for the role of income, we observe a negative association between the level of income and purchase intention. In particular, passengers with lower income display higher propensity to purchase during all stages of travel (parameter estimates of 0.77, 1.00 and 1.13 for departure airport, flight time and transfer airport respectively) whilst those with higher income show lower propensity to purchase at the departure airport and in-flight (−0.65 and −0.98), compared with medium income travellers. In addition, we also observe that unemployed people show more interest in purchasing at the departure airport compared with employed people (parameter value of 0.86). In conclusion, there is sufficient evidence emerging from the model to support *H3*, i.e. shopping decisions are driven at least partly by passenger sociodemographic attributes.

As for the fourth hypothesis (*H4*) about the time of travel, we observe that flights taking off between midnight and 06:00 were associated with a higher likelihood of sales onboard and at transfer airports, with parameter estimates of 0.62 and 0.53 respectively. In addition, travellers on trips with duration of up to 6 h were less likely to spend money at the departure airport and in-flight (parameter estimates of −0.56 and −0.30 respectively). It is also worth recalling that trip duration and departure time were associated (as per *H2*) with specific purchase of products and services, such as food and beverages, gifts, souvenirs and children's products and toys. All that points towards supporting our hypothesis *H4*, i.e. amount of time spent at the airport, duration of flight and time of day of travel impacts purchase decisions.

With regards to the fifth hypothesis (*H5*), we observe that passengers accompanied by children (aged under 15) are more likely to purchase at the departure airports and in-flight (parameter estimates of 0.47 and 0.37 respectively) when compared to people who travel alone or with friends, colleagues, or other family members. Furthermore, being accompanied by a child or children was observed to play a role in whether and when fashion, cosmetics, accessories or gifts, souvenirs and children's products and toys constituted expenditures at the airport or in-flight. Considering the above, we conclude that we have enough evidence to partially accept *H5*, ie we accept it for departure airports and flight time, but not for transfer airports.

Lastly, the sixth hypothesis (*H6*) looks at the role of an international context, purpose and class of travel. Passengers on business trips were more likely to spend money at departure and transfer airports (parameter estimates of 0.54 and 1.34 respectively) compared to those travelling for other reasons. At the same time, passengers travelling in premium class were on average more likely to make purchases during the flight, compared to other travel classes. Importantly, several effects related to trip purpose and class of travel have already been discussed above in reference to purchase of fashion, cosmetics, accessories, food and beverages as well as travel essentials. Interestingly, testing for the association between purchase and international travel did not yield statistically significant results. Hence, we observe a partial support for the hypothesis *H6*, i.e. there is evidence for the role of purpose and class of travel on decisions to shop and how much to spend across different stages of travel, but insufficient evidence for the role of international travel.

## 5. Discussion and conclusions

### 5.1. Discussion of the findings and implications for the sector

Responding to the need for research into the drivers of non-aeronautical and ancillary revenues for airport and airlines respectively, this study examined the role of traveller attributes, trip context and product and service type in determining how much is spent at departure and transfer airports as well as in-flight. The empirical analysis uses survey data from passengers travelling from four multi-airport cities around the world, specifically London, New York, Shanghai and Sao Paulo. The proposed MDCEV model, applied for the first time in this context, has demonstrated the ability to recover and reflect average spending levels for the different city contexts and trip stages via the satiation parameters. This provides reassurance concerning its operation and validity, paving the way towards its use in further studies.

Six hypotheses are proposed to examine several groups of factors associated with the decision to purchase and how much to spend. At a high level, the results confirm that shopping decisions involve an interplay of interactions between trip context, traveller attributes, the type of products and services. The specific findings obtained in the current analysis are in line with the existing observations. For example, the importance of age is consistent with the findings in the literature of impulsive purchases (Bashar et al., 2013; Bellenger et al., 1978) and airport retail (Del Chiappa et al., 2016), where age was shown to play a crucial role in search and purchase behaviour. Similarly, reduced preference for alcohol and tobacco products may indicate a certain generational preference (since purchasing power is controlled for via income variables), though the evidence for this global trend is not conclusive (World Health Organization, 2019).

Explanation of other effects, such as the propensity of lower income or unemployed individuals may be related to behavioural underpinnings, such as reflection of the 'happy hour' context mentioned in section 2.2, where the relief may create an elevated propensity to shop. The observed effects related to travelling with children are consistent with the study by Castillo (Castillo-Manzano, 2010) and possibly indicative of children getting bored and having to engage in activities before and during flight. This in fact applies to all travellers, as both the results of this study as well as the existing literature (Appold and Kasarda, 2006; Castillo-Manzano, 2010) confirm that longer stay at the airport and longer flight duration make passengers more likely to purchase products and services. This highlights the value of shopping opportunities as not just a means for airlines and airports to generate additional revenue, but also a way to improve the overall passenger experience.

The consequence of the observed heterogeneity in preferences is the need to shift towards more tailored retail approaches by airports and airlines. First, this means marketing strategies that are tailored to a specific combination of trip and individual factors. With the proliferation of mobile apps for travel management and assistance, data about

travellers and their trips can be harnessed in line with observations established in this analysis to provide genuinely personalised offerings, either via the apps themselves or via guidance to staff in terms of which products to market at which stage of travel.

Knowledge of shopping preferences can also be used to optimise supplies, though at the cost of additional management complexity. Naturally, such personalised strategies will require a careful approach in terms of data handling and communication with the customers, to conform with data protection legislation and to remain ethical and trustworthy from the customer perspective.

The analysis also confirmed that shopping behaviour of air passengers is correlated with the more traditional segmentation, such as class of travel. For example, passengers with premium economy class tickets show a greater propensity to purchase during the flight. This could be a result of the fact that business class and first-class passengers enjoy better services (both at the airports, in the form of lounges, and on-board) and do not feel the need to shop onboard, whilst on the other hand economy passengers may be less interested in shopping overall (given the higher cost sensitivity of this segment). Nonetheless, a lower fraction of passengers (by about 20–30%) shopping during flight compared to the airports (departure and transfer), indicates a possible revenue enhancement opportunity to be explored by the airlines. This lower preference for purchasing during flight may be indicative of the lack of sufficiently attractive offers or the lack of information concerning the availability of certain products on-board, e.g. cosmetics, encouraging the passenger to purchase before boarding. To capture this customer base, airlines would need to inform passengers about the on-board offers prior to boarding, even allowing them to make the purchase before boarding (with on-board pick-up). Systems to support such services are now customarily used by airlines for indication of food preferences or pre-flight meal purchases, which arguably opens avenues for adapting such systems to wider retail opportunities.

From another standpoint, understanding shopping preferences within airports can assist in planning of the retail space. The current analysis established that transfer airports are where people spend most of their money, partly due to having limited alternatives during a flight involving multiple legs. Unsurprisingly, transfer airport contexts are characterised by average expenditures that are higher than the departure airports (by 20–60%) in 3 out of the 4 city contexts studied in the present analysis. This should motivate retail planning approaches that can not only guide location and stocking of fixed retail units, but also consider more dynamic, mobile retail spaces, including food and coffee carts, entertainment spaces (for children and adults alike), mobile kiosks as well as in-terminal online purchase and delivery options (lockers, delivery points). Layout of such flexible retail opportunities, operating hours and so on, should then consider arrival and departure plans or even expected passenger profiles. The modelling results offer some insights towards target segments for such arrangements. For departure airports, short flights and those at late hours are when people are less likely to shop before the departure, especially high-income travellers. Similarly, we observe lower propensity to purchase food and beverages by business class passengers or to shop for fashion and cosmetics by first class travellers and those on business trips. We interpret the results above as indicative of a need for greater convenience in browsing and purchasing, given the relatively high value of time of this segment as well as their higher desire for comfort and ease-of-access to high-quality products.

Another context requiring reflection is that of COVID-19, especially in light of the dataset referring to pre-pandemic travel. Whilst the impact of the associated travel restrictions and lockdowns on air travel was unprecedented, recent data are consistently showing the air travel industry being on a pathway towards full pre-pandemic recovery in terms of passenger-kilometres, seat capacity and air ticket sales (Air Passenger Market Analysis, 2023). During the pandemic, there was an expectation of reduced shopping at airports as a means of limiting contact with staff or other passengers (Airport World, 2020). Recommendations were made for adapting to such conditions, by reinventing shopping formats, focusing more on the experience (in terms of the products and services but also the shopping itself), as well as better use of data in managing relationships with customers, such as personalised offers (Roland Berger, 2022). Whilst evidence is only just emerging regarding air travel retail performance post-COVID, so far it points towards a consistent recovery though at a pace below that of the general demand recovery (Inside Retail, 2023; The Moodie and Davitt Report, 2023). Uniquely, this study provides a benchmark against which similar analyses using more recent data could be carried out, to understand in more detail the impacts of the pandemic shock on the air travel retail sector.

### 5.2. Directions for further research

Concerning future directions of the research in this space, observations from the current analysis highlight the need for research focused more specifically on passengers at transfer airports. Given that such passengers spend the most, insights into what products and services they choose to purchase and how it relates to their trip and personal contexts appears to be a particularly valuable area for further research.

Another line of inquiry should look into more detail at what determines the purchase of specific product and service types, by capturing the prices and other characteristics, especially in relation to availability (or not) of such products/services at various stages of travel. The role of information concerning such product/service availability also requires investigation, in line with the overall intention of tailoring retail offerings towards customer preferences. More broadly, an expanded pool of variables that may affect shopping behaviour is warranted, including via similar quantitative approaches and expanded surveys but also via smaller sample, exploratory studies, such as focus groups, where more intricate links between variables may be revealed or causality can be directly validated.

In addition, the data used in this paper relies on self-reported online surveys, which may be subject to mis-reporting or recall bias. Validation against different types of data sources, such as intercept surveys or sales data, could shed light on the relative merits of such methodologies. As for the methodology employed in this paper, the present contribution offers the use of arguably one of the most comprehensive econometric frameworks for handling discrete-continuous modelling contexts. However, the research field would certainly benefit from a comparative study that assesses the relative merits of various modelling methods for air travel retail behaviour.

Finally, the recovery of air travel demand has led to growing discussions concerning environmental impacts of mass air travel, especially considering the more extreme weather and climate observations increasingly linked to anthropogenic emissions. There is a direct relationship between these phenomena and the retail industry i.e. increasing aircraft payload by carrying goods for on-board sale or increasing airport resource consumption; there is also an indirect relationship as the retail offerings can improve the overall passenger experience thus increasing the demand for air travel. Whilst airlines and airports have begun to address some of these challenges as part of their overall operational efficiency improvement, e.g. pre-flight ordering, it remains to be researched how such strategies will affect overall passenger expenditure and experience against their effectiveness in mitigating negative environmental impacts.

## Availability of data and material (data transparency)

Data access requests can be made to the authors.

## Code availability (software application or custom code)

The supporting codes and analytical files can be provided upon request.

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None.

## CRediT authorship contribution statement

**Suyang Li:** Writing – original draft, Methodology, Formal analysis, Data curation. **Jacek Pawlak:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Aruna Sivakumar:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

## Data availability

Data will be made available on request.

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