Effects of terminal planning on passenger choices

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Abstract

This paper deals with passenger activity choices inside an airport terminal. The objective is to study the impact of space configuration on passenger behavior. A two-step approach is followed. At first, space configuration is assessed by using the Space Syntax method. Then, a logit model is specified in order to explain passenger choices over different coffee areas in an airport. The methodology is applied to the case of Lisbon Portela airport. For the purpose of this study a survey has been conducted and data related to passenger characteristics, time, trip, and passenger activities have been collected. Two preliminary models were formed which included space characteristics as retrieved from the Space Syntax analysis and data collected in the survey. Space characteristics are found to affect the choices of the passengers. The paper concludes with some proposals for further specifications and different model structures that could capture passenger choices in airport terminals.

Keywords

Discrete choice models – Space syntax – airport terminal planning – passenger activities

1. Introduction

Airports are complex facilities that accommodate both aeronautical and non-aeronautical activities. The first ones are mandatory for the passengers while the latter ones are discretionary and might be located before or after the check-in and the security areas. The services that the passengers enjoy at the discretionary activities are of various types and might range from clothing shops to personal well-being centers. Nowadays, many airports regard such services as alternative sources of revenues. Depending on the type of the airport (hub, low cost, business etc) the diversity of the available activities differs and the time that the passengers devote to them varies. For instance, it is believed that in medium sized European airports, the passengers prefer to use such services after the security control process because they want to reach their gate fast and they are more concerned with their preparation for their air travel. It is more common that the passengers who spend a lot of time at those services are those with long transfers as well as those who arrive at the airport with relatives or friends. Also, cultural issues may drive the choice decision of the passengers. For example, from a survey conducted in Lisbon airport in April 2012, it was observed that people from North European countries preferred to spend time at the areas located outside the airport and enjoy warm weather instead of performing activities indoors, after the security area and closer to their gate.

In contrast to open space, indoor movements are more likely to invoke purposive and not exploratory walking behavior. Passengers in an airport are more likely to have a specific destination than moving randomly around the airport. From the literature, there is evidence that the accessibility of retail areas is a crucial factor for the total retail revenues of Chiang Kai-shek International Airport (CKS) in Taiwan (Hsu and Chao, 2005). More recently, Lin and Chen (2013) found that passenger shopping motivations at Taiwan’s Taoyuan International Airport had positive impacts on the commercial activities at the airport, and that time pressure and impulse buying tendency affect shopping motivations and commercial activities. A more methodological approach was followed by Hoogendoorn and Bovy (2004) who developed and applied an activity-based model, which included at a second level route choices, in order to model passenger choices inside Amsterdam Schiphol airport. Finally, Canca, Zarzo, Algaba and Barrena (2013) have also developed a discrete-time, macroscopic attraction-based simulation model that could be employed for indoor pedestrian mobility studies. Issues related to destination attraction, location and the route chosen were addressed.

This study aims to explore the impact of spatial features on passenger choices over the location of activities which offer the same services inside an airport terminal. Such a model could later be used to forecast changes in passenger choices under different future scenarios, expressed as a combination of different space configurations, passenger characteristics and airport processes. The remainder of the paper is organized into four sections. Section 1 shortly describes airport processes. The second presents the methodology that will be applied in this paper. The third one includes the description of data collection, presents the results of a case study and discusses two model specifications. Finally, in the fourth section, some conclusions are made and future research is presented.

2. Airport processes and passenger categories

An airport can be separated into two key areas, the landside and the airside. The landside includes all the areas that the passengers use before their departure or after their arrival at the airport. The airside entails all the areas that are used for the activities related to aircrafts.

Passengers and those who accompany them perform many tasks within the terminal building. They can all move in the airport in all the areas before the security control and the passengers have to pass through the check-in process, the security screening, the passport control, customs and immigration, and the boarding gate. Along these procedures, their needs can differ according to personal, social and cultural characteristics.

Different passenger categories can be formed depending on the criterion used to organize them. Possible passenger segmentation can be made according to: destination, purpose of the trip, role of the airport at the trip, type of the flight and use of baggage or not. The resulting passenger segments are presented below:

- Destination: International and Domestic
- Trip Purpose: Business and not business
- Role of airport in the trip: Final destination and transfer
- Type of flight: Regular, low cost and charter
- Baggage or not: Passengers with and without baggage to be checked in.

The "journey" of the passengers from their entrance to the airport until the boarding to the aircrafts includes all the required processes that take place in the building, require the passenger participation and ensure the preparation of the passengers for their air trip. Checked-in baggage goes through a separate process of successive security screenings of increasing sophistication using different technologies, until they are transferred to a central area and then through belts they arrive at the gates. Then they are transferred to the airplanes through special vehicles. These processes are differently distributed in the airport building depending on a set of criteria that are discussed and evaluated by the responsible groups for the planning of each airport. Given that there is available time, in between the aeronautical activities, the passengers can spend time at non-aeronautical activities. Each airport according to the type of the traffic that it attracts it can decide to offer different choices to the passengers.

3. Methodology

In order to study passenger activity choices inside an airport a two-step approach is followed. At first, space configuration is analyzed and then the effect of spatial attributes on passenger choices is explored. For the first part, Space Syntax is used for the quantification of space characteristics. At the next step, the driving forces for the choices of the passengers are investigated using choice models.

3.1 Space syntax

Space Syntax (SS) is a theory and a set of methods about space, reflecting both the objectivity of space and our intuitive engagement with it (Hillier, 2005). The concept and the relevant methodology were first developed by Hillier and Hadson (1984). Jiang and Claramunt (2002) underlined that one of the founding ideas of SS Theory derives by an attempt to understand how spatial configuration influences the movements of people inside it. The representation and quantification of characteristics of the built environment have the potential to be used as independent variables for a statistical analysis of pedestrian behavioral patterns (Penn, 2003). The analysis includes the representation of space as a set of convex spaces or a set of axial lines (Turner, 2007).

Space can be considered either as an axial, convex or isovist. Axial space is a space where no line between any two of its points crosses the perimeter (Klarqvist 1993). Convex space can be defined manually by separating space into the smallest number of largest convex subdivisions (Carvalho and Batty, 2003). Finally, an isovist is the total area that can be viewed from a point (Klarqvist 1993). The corresponding maps of these spaces can be designed. Attention has been paid to axial maps that have been found to adequately represent human movement patterns (Turner and Penn, 2002) while the last space type, isovists, is an adequate means to evaluate space configuration (Hillier, 2004).

Hillier (1989) was the first to present some measures that describe space characteristics and quality. **Connectivity** is a measure that expresses the number of “neighbours” of each line or space. In particular, it is the number of the axial lines or convex spaces that are directly connected to any line or convex space. The concept of **integration** is related to the location of a line or space in relation to all the others. It employs the depth measure to calculate how “deep” or “shallow” the specific line/space is when conceptualizing the configuration of the entire layout which is under examination. A space is said to be integrated when all the other places are shallow from it, namely, when a pedestrian has direct accessibility to them without having to pass through other spaces. In general, this measure could be regarded as an ***equivalent of accessibility***. Although accessibility in geographical science counts the ease of opportunities in an environment, in space syntax theory it is a measure that counts for the shallowness or closeness centrality from every space to every other space where the cost is calculated as a function based on the configuration or geometry of the grid (Law et al. 2012). ***Depth*** expresses the number of steps (i.e. changes in direction) that are required to be performed before reaching one’s destination. The value of depth varies depending on how many other spaces a pedestrian has to move through in order to reach the referenced space. It might refer to adjusting or more remote spaces. In relation to integration, when a space is found to have a low value of depth it is considered as integrated while when it is found to have a high value of depth it is regarded as segregated implying the need to pass through different spaces in order to reach it. The ***control value*** measures the degree to which a space controls access to its immediate neighbors taking into account the number of alternative connections that each of these neighbors has. The degree to which integration and connectivity correlate to each other is defined as the ***intelligibility*** of the system and it indicates how easily an area can be found.

3.1.1 Space syntax application

The afore-presented theory can be applied in studies mainly related to the design and planning of pedestrian facilities. In the literature it was found that space syntax has been applied both to the analysis of the urban environment and of indoor movements of pedestrians in public facilities. Studies that tackled with problems related to pedestrian movements will be briefly presented.

Hospital design layouts have been studied with the objective to improve operational efficiency, patient flows and patient satisfaction (Vos et al. 2007, Tzortzopoulos et al. 2009, Khan 2012). Hospital intelligibility has been designated as an important predictor of pedestrian wayfinding and environmental cognition (Haq and Girotto 2003). In a study of a conference centre, the usability of “hotspots” was clearly related to the values of depth, connectivity and integration (Brösamle, Hölsher and Vrachliotis, 2007).

The configuration of commercial buildings has been studied in terms of pedestrian flows (Zhang et el., 2012) and sale rates (Fujitani, 2012). The factors that influence pedestrian flows in three multi-level commercial areas in Shanghai were studied by Zhang et al. (2012). The horizontal configuration, the distribution of the entrances, the variation of levels and the setting of vertical transitional spaces were found to have a high impact on the configuration of the building. In particular, integration was designated as the most influential factor, followed by a vertical transitional indicator. In contrast, the effect of the entrance location and the level variation were found to be of low importance. Store identity and pedestrian visibility were the most influential factors in people's behavior when moving at the same level, while for the transition to a different level the entrance location was the prominent variable.

In the transport sector, issues related to sidewalks, accessibility and pedestrian flows have been explored. Jiang and Gimblett (2002) performed a regression analysis of the space syntax integration value with pedestrian rates derived from an agent-based model. Both the static characterization of the layout from space syntax and the dynamic representation of pedestrian flow from agent-based models can provide insight into the role of the spatial layout in movement. The activity levels and the corresponding pedestrian movement patterns in the area of Galata, Turkey, were analyzed by Ozer and Kubat (2007) who used space syntax and a multi-regression analysis. The sense of safety, space accessibility and land-use patterns were designated as the factors that play an important role in the prediction of activity levels. At another study, the visibility of pedestrians, the number of turns and distance were the factors that were identified as crucial for passenger route choices within Shibuya subway station in Tokyo (Ueno, 2009).

There is some evidence that space syntax has provided insight in pedestrian choices. For this reason, it will also be included in this study to check the impact of spatial characteristics on passenger choices inside an airport building.

3.2 Discrete choice modelling

Discrete choice models are used to explain a decision maker's choice over a defined set of alternatives. The aim is to use attributes of the different alternatives, characteristics of the decision-maker or interactions of these factors in order to explain the choice of the decision maker. The logit model and the nested logit model are commonly used in applications.

The concept of utility is introduced to express the benefits that the decision maker gains from the choice of the specific alternative. The deterministic utility of an alternative i for an individual n is expressed as the sum of the deterministic utility and a random component ε_{in} that captures the errors in the model due to several sources, such as unobserved alternative attributes, unobserved individual characteristics, measurement errors and proxy variables (Ben-Akiva & Lerman, 1985):

$$U_{in} = V_{in} + \varepsilon in$$

Different types of variables can be used, such as generic for all the alternatives, specific for some of the alternatives or socioeconomic which are related to the decision makers' characteristics.

The probability (P_{in}) of a decision-maker, n, to choose an alternative, i, over a set of alternatives C_n is given by the formula:

$$P_{in} = \frac{e^{V_{in}}}{\sum_j e^{V_{jn}}}$$

In order to assess the actual impact of the variables in the choices of individuals, different specifications can be tested. For each of them the parameters are estimated by maximum likelihood, and various statistical tests are applied to assess the quality of the specification.

4. Case study

Lisbon Portela airport is now used as a case study. It is the biggest airport of Portugal located in the capital. It has two runways and two passenger buildings. In 2013 the total number of passengers was around 16 million passengers.

The check-in floor is included in this study and the scope of the analysis is restricted in the choices of the departing passengers since their arrival at the airport until reaching the security area.

4.1 Space configuration

At this airport different discretionary activities are dispersed in the building and no activity concentration is observed. There is also lack of open space areas. This type of configuration presumes that the pedestrians have to move in between these areas and as a consequence the space available for the passengers to make decisions about their way seems to be limited; they should adjust their movements to a labyrinth layout. It is presumed that the visibility from some entrance points and passenger perception of the space from them low because of the multiple obstacles located in their view field. Especially for first-time passengers this might be confusing since they have to rely on the signage system in order to orient themselves. Taking into account the stress of the passengers inside a terminal not to miss their trip, this can have many implications to wayfinding and reduce the perceived level of service.

4.2 Discrete choice model

The case study airport has four coffee places, three of which are located exclusively inside; the last one has an outdoor part too. Other discretionary activities are also available. The passengers can visit a shopping and a lounge area, or wait at benches located at different parts of the airport. At this study these discretionary activities will not be taken per se into consideration. Under the assumption that the areas where services of the same type are offered constitute a potential nest of activities, we start the analysis of passenger activities from this first, basic level with the intention to complicate the exploration of passenger choices at a second level. The total number of the activities that the passengers perform before going to the security area is of our interest but not their sequence. The total time spent at all the discretionary activities will also be included in the analysis. In this study, we consider a logit model to capture the choices of passengers over coffee places in this airport before the security process.

4.2.1 Data collection

The data collection process was general and it was not oriented to one passenger segment. A revealed preference survey was conducted to collect information over the activities of the passengers inside the airport upon their arrival at the airport until passing the security area. The data collection took place during one week of March 2014 from 10am-9pm. The passengers were randomly asked to participate at one of the following three phases:

- At the locations of discretionary activities
- While walking around
- At the security control area

The structure of the survey consisted of groups of questions related to time, personal information, trip information, activities inside the airport and wayfinding issues.

Structure of survey

Time: At first the passengers were asked to provide the time that their flight departs and how much time in advance: they arrived at the airport, they performed (if necessary) the check-in, they planned to reach or reached the security area and when they would like to arrive at their gate. This type of information would provide insights over the time preferences of the passengers and the time risk they decide to take.

Personal information: In order to be able to relate passenger choices to passenger types, personal information was gathered. Particularly, this group concerned the age, the gender, the trip purpose, the nationality, the city of residence, air travel frequency, stress for flight, stress for time and familiarity with the airport building.

Air trip information: Aspects pertinent to the airline, the destination, the number of baggage, the mode of check-in and the mode of arrival at the airport were collected from this section of the survey. In addition, the passengers were asked to report the number of passengers they travel with, the number of non-travellers with whom they arrived at the airport and, in the case that they arrived by car, whether they used the parking or not.

Activities: At this section the passengers were asked to report the activities they performed inside the airport since their arrival until reaching the security control area. Such information indicates the activities in which the passengers distribute their time before going to the security area and delineate the main attractors that make them divert from their intermediate aeronautical destination, namely the security control area. For the activities that offer the same service (ex. coffee) the passengers were asked to indicate the criterion with which they chose the activity. They were shown a certain group of criteria (ex. visibility, availability of seats, proximity to security etc) and they revealed which of them guided their decisions.

Wayfinding: Issues relevant to the easiness to move inside the building were given through this section. The passengers were asked to recall if they used the flight information board and the signs, if they got lost inside the building and if they used any point as a landmark. Finally, they attributed the building a grade as an evaluation indicator for wayfinding.

Every passenger who participated in the survey was asked questions related to the aforementioned categories and he also indicated his itinerary on a plan.

4.3 Model specification and estimation

Several types of variables were considered to affect passenger propensity to choose an alternative. For each alternative, a deterministic utility function should be built. Since the case study airport has four coffee areas, four utility functions were assumed, VC1, VC2, VC3 and VC4. The variables considered were related to the five categories employed to construct the survey (time, personal, trip, activities, wayfinding) which were mainly characteristics of the decision makers, i.e. the passengers and spatial characteristics of the alternatives. Hereafter, the factors that will be tested and are, intuitively, expected to affect passenger choices are organized:

a) **Attributes of the alternatives**: It is expected that visibility from the entrance and the check-in points will increase the utilities of the alternatives. In addition, the visibility from the previous location of the passenger might affect his choice over the alternatives.

b) Passenger characteristics: The feeling of familiarity with the airport and the value that the passengers attributed to the wayfinding system of the airport are anticipated to reveal passengers' preferences across the alternatives.

c) Interactions of attributes of alternatives and passenger characteristics: This type of variables is created to capture heterogeneity in the population and reveal the "taste" of distinct segments. It is assumed that age will have an impact on the choice of the passenger in terms of the distance of the activity from the check-in area or the change of floor inside the building.

The available time that the passengers have before flight departure is expected to affect their choices in relation to the distance from the security control area. Passengers who use the building for the first time are expected to choose places that are close to the check-in and can be visible from the check-in area. In addition, the number of people that the passenger travels with and the number of people that accompany him at the airport are expected to increase the utilities of the alternatives that have higher seat capacity. The time that passengers spend at the activity area is expected to decrease the utility of the alternatives that are located away from the security control area. Stress is also expected to decrease the utility of the alternatives located close to the security area. The passengers who are not familiar with the airport configuration are expected to be more sensitive to choices that are visible from their previous activity since they are not aware of the airport and the allocation of space inside it. Distance is introduced in the utilities of the alternatives to account for its impact on the choices of the passengers who are required to use the check-in area either for their ticket or their baggage. A negative impact is anticipated for this aspect; an increase in the distance of the coffee place from the check-in is expected to cause a decrease in its utility.

Following the logic of space syntax, two more attributes are expected to have an impact on the utilities of the alternatives, integration and connectivity. Integration, as a global indicator of space syntax, is expected to increase the utility of the alternatives for the passengers who only use a coffee place and do not perform any other activity. In particular, when assuming random walking as an activity and integration as a measure of accessibility, the passengers who visit a coffee place without having walked around the airport area, are expected to perceive as a benefit an increase in the integration compared to those passengers who perform more than one activities and are more likely to be aware of the configuration of the airport and the alternatives they have. To assess the impact of the feeling of familiarity to the afore-presented interaction, the aspect of familiarity can be added in this interaction.

Another spatial attribute of the alternatives is connectivity which is a local measure and which would be expected to affect the utilities positively for the passengers who choose to go to a coffee place after the check-in process. The logic behind this assumption lies on the fact that this type of passengers has the same origin type and has to choose between a specific set of destinations. Hence, the geometrical scale is limited. Connectivity is an indicator that characterizes the location of an area in terms of adjacent connections and does not express the connectivity of two specific areas. Consequently, at a local scale connectivity can imply a higher probability of a passenger to choose a place. In addition, when connectivity is studied as an interaction with the distance from the check-in areas it could shed light on the importance it has to passengers who move from the check-in area to their activity area.

The afore-mentioned assumptions will be tested through the modelling process. At first, a base model was constructed with alternative specific constants, the visibility from the check-in zone (VIS_{CiC}) and the entrance (VIS_{CiE}), the integration (integ_ci) of the alternative and its connectivity (con_ci).

$$V_{C1} = ASC_{C1} + \beta_{ENTVIS} * VIS_{C1E} + \beta_{CHVIS} * VIS_{C1C} * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c1 * OnlyCoffee + \beta_{CON} * con\_c1 * coffeeAfterCheckIn$$

$$V_{C2} = ASC_{C2} + \beta_{ENTVIS} * VIS_{C2E} + \beta_{CHVIS} * VIS_{C2C} * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c2 * OnlyCoffee + \beta_{CON} * con\_c2 * coffeeAfterCheckIn$$

$V_{C3}= ASC_{C3} + \beta_{ENTVIS} * VIS_{C3E} + \beta_{CHVIS} * VIS_{C3C} * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c3 * OnlyCoffee + \beta_{CON} * con\_c3 * coffeeAfterCheckIn$

$V_{C4}= ASC_{C4} + \beta_{ENTVIS} * VIS_{C4E} + \beta_{CHVIS} * VIS_{C4C} * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c4 * OnlyCoffee + \beta_{CON} * con\_c4 * coffeeAfterCheckIn$

The visibility from the check-in area was introduced with a specific parameter for each alternative because it was assumed that the impact on each alternative would be different. On the contrary, a common effect was assumed for the visibility of the coffee place (VIS_{C1E}) from the entrance that the passenger used. The same applied for the interaction of the integration value and the fact that the passenger performs only one activity, namely he visits a coffee place (INTEGonlyCoffee). The fourth aspect that was inserted in the utilities was the joint effect of connectivity and the fact the passenger chooses an alternative after finishing the check-in process.

The choice to use generic or specific parameters for each of the attributes included in the alternatives was confirmed after comparing the equivalent models through the ratio test, indicating that the 4^{th} alternative presents some peculiar characteristics compared to the other three. The afore-presented model was proved to be more representative and for this reason it will be used as a base model for the analysis. Despite the traditional approach of using pure attributes of the alternatives in the base model, in this case this was not feasible because of the nature of the data and the choice issue that is under study. The available data that can be used as attributes for the alternatives does not change among the respondents as the variables refer to spatial characteristics. For example, the connectivity and integration values remain the same for each alternative regardless of the user. The specification is presented in Table 2 and the results of this model are presented in the second column of Table 3.

After formulating the base model, more variables were tested gradually to assess their effect on explaining the choices of the passengers over the offered alternatives. In this attempt to build on the base model, at each trial the contribution of the added variable was assessed by performing the likelihood ratio test. The final changes added in the utilities are hereafter presented:

- Familiarity with the airport configuration was included in the utilities of the first three alternatives. The use of specific parameters was not found to result in a better model.
- Assuming that the passengers behave differently when they travel alone than when they travel in groups, the corresponding variable was introduced in the utilities of the first three alternatives to explore its impact compared to the last one (TravelAlone).
- Accordingly, the time that the passengers spent in the activity area (SPENTtime) was added in the utilities of the first three alternatives. In order to assess the feeling of stress to move inside the terminal, a relevant variable was added in the utility of the

first three alternatives in relation to the time that the passengers spent at the activity area (TIMEstress).

Table 2 presents the specifications of the models and in Table 3 the analysis results are shown for the base and the improved model.

Table 2. Models' specifications

	Variables	C1	C2	C3	C4	
	ASC_C1	1	---	---	---	
	ASC_C2	---	1	---	---	
	ASC_C4	---	---	---	1	
	VISIBILITY_CHECKIN_1	VISC1C	---	---	---	
Base Model	VISIBILITY_CHECKIN_2	---	VISC2C	---	---	
	VISIBILITY_CHECKIN_3	---	---	VISC3C	---	
	VISIBILITY_CHECKIN_4	---	---	---	VISC4C	
	CONNECTIVITY_AFTER_CHECKIN	con_afterCheckIn	con_afterCheckIn	con_afterCheckIn	con_afterCheckIn	Enriched Model
	VISIBILITY_ENTRANCE	VISC1E	VISC2E	VISC3E	VISC4E	
	INTEGRATION_ONLYCOFFEE	integ_OnlyC1	integ_OnlyC2	integ_OnlyC3	integ_OnlyC4	
	FAMILIARITY	familiar	familiar	familiar	---	
	SPENTtime	spentT	spentT	spentT	---	
	TIMEstress	stressT	stressT	stressT	---	
	TravelAlone1	aloneTr1	---	---	---	
	TravelAlone2	---	aloneTr2	---	---	
	TravelAlone3	---	---	aloneTr3	---	

Table 3. Estimation results for the base and the improved model

Variables	Base Model		Enriched model	
	Parameter value	t-test	Parameter value	t-test
ASC_C1	-0.345	-1.02	-0.526	-1.30
ASC_C2	-0.548	-1.46	-0.821	-1.95
ASC_C4	-1.22	-2.91	0.135	0.22
CHECKVIS1	-0.589	-0.98	-0.618	-1.03
CHECKVIS2	0.768	2.15	0.766	2.13
CHECKVIS3	-1.09	-2.54	-1.07	-2.48
CHECKVIS4	0.794	1.89	1.03	2.24
CONNECTIVITY	0.0244	2.49	0.0205	2.05
ENTRANCEVIS	0.582	2.99	0.563	2.85
INTEGonlyCoffee	0.0215	1.94	1.07	2.60
FAMILIARITY			0.0228	2.04
SPENTtime			0.0295	2.11
TIMEstress			-0.0366	-2.33
TravelAlone1			1.08	2.02
TravelAlone2			1.25	2.68
TravelAlone3			0.782	1.70

The expected outcomes were given by the model for the visibility from entrance and the check-in areas. Visibility of C2 from the check-in areas was found to have a positive impact on its utility (the highest impact compared to the rest of the alternatives). For C4, visibility from the check-in also had a positive but less strong influence. In contrast to these alternatives, the equivalent impact on the utility of C1 and C3 was negative showing that these alternatives are less likely to be chosen when they are visible from the check-in zone. Although it was attempted to explore the impact of adding the distance from the check-in in this interaction, it was not found that it could improve the existing model. This could be further explored by studying the interaction of visibility from the check-in with passenger characteristics.

In relation to the spatial characteristics of the alternatives, the results of the model showed that an increase in the integration level of the activity location could add value to the passengers who perform only one discretionary activity, in this case, choose to go to a coffee place. Hence, the aforementioned assumption that was made for this interaction was corroborated by the results of the model. This result was consistent with the assumption made since integration is a global indicator of SS and can be interpreted as the accessibility of a location. At a local scale, for the passengers who visit the choice locations after the check-in, connectivity was found to be an important factor that affects positively the passengers' perception for the utility of the alternative. This also coincides with the presumed hypothesis that was made before the modelling process.

When considering the time that the passengers spend at the activity location, it was shown that a passenger who chooses to spend a lot of time at the activity area, is more likely to choose one of the first three alternatives compared to the fourth one when the rest remains the same. This would be expected as the capacity in seats of the fourth alternative is smaller compared to other three and it offers more standing places. The aspect of stress was also tested as an interaction with the time that passengers spend at the activity area and the result showed that the passengers who experience stress inside the airport in relation to time availability would prefer the fourth alterative compared to the other three. This result is acceptable as C4 is located close to the security area and it would be expected to be chosen by passengers who want to feel that they can reach security as fast as possible. Despite this observation, any trial to include the distance from the security area was not successful neither when considering different transformations of the variable nor when testing interactions with passengers' characteristics such as the time spent, the ratio of the time spent to the total available time, the residence or the intention to go directly to the gate after passing the security control.

The results also indicated that if a passenger travels alone, it would be more likely him to choose C2, followed by C1 and finally C3 compared to C4 assuming that the rest of the utilities were the same. As for the feeling of familiarity with the airport configuration, familiar passengers showed a preference for C1, C2 or C3 compared to C4.

All the aspects that were expected to have an impact on the utilities were tested during the modelling process. However, some of them were not found to be important and were not presented in Table 2. For example, any attempt to add the distance variable in the utilities of the alternatives failed indicating that it does not constitute an important choice factor for this part of the airport. In contrast to what was assumed, the ratio of the time that the passengers spend at the activity area to the total time they have available inside the airport until flight departure was not significant for the choice of a coffee place. This characteristic could be designated as important in a more general level at which activities which offer different types of services would be included in the analysis. Other variables that were not found to explain further the passengers' choices were: baggage, number of accompanying people at the airport, the planning of the activities before arriving at the airport, age, first-time user, wayfinding, the type of the flight (Schengen, non-Schengen, transfer) and interactions of these variables with attributes of the alternatives.

The ratio test showed that the improved model is better than base model and it can represent better the choices of the passenger population.

The final utilities of the alternatives are formed as follows:

$VC1 = \beta_{ENTVIS} * VISC1E + \beta_{INTEGonlyCoffee} * integ\_c1 * OnlyCoffee + \beta_{CONNECTIVITY} * con\_c1 * coffeeAfterCheckIn + \beta_{FAMILIARITY} * familiar + \beta_{SPENTtime} * SPENTtime + \beta_{TIMEstress} * TIMEstress + \beta_{TRALONE1} * TravelAlone1$

$VC2 = ASCC2 + \beta_{ENTVIS} * VISC2E + \beta_{CHVIS} * VISC2C * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c2 * OnlyCoffee + \beta_{CONNECTIVITY} * con\_c2 * coffeeAfterCheckIn + \beta_{FAMILIARITY} * familiar + \beta_{SPENTtime} * SPENTtime + \beta_{TIMEstress} * TIMEstress + \beta_{TRALONE2} * TravelAlone2$

$VC3 = \beta_{ENTVIS} * VISC3E + \beta_{CHVIS} * VISC3C * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c3 * OnlyCoffee + \beta_{CONNECTIVITY} * con\_c3 * coffeeAfterCheckIn + \beta_{FAMILIARITY} * familiar + \beta_{SPENTtime} * SPENTtime + \beta_{TIMEstress} * TIMEstress$

$VC4 = \beta_{ENTVIS} * VISC4E + \beta_{CHVIS} * VISC4C * doCheckIn + \beta_{INTEGonlyCoffee} * integ\_c4 * OnlyCoffee + \beta_{CONNECTIVITY} * con\_c4 * coffeeAfterCheckIn$

5. Conclusion and future research

The models showed that space characteristics, and specifically integration and visibility, have an impact on passenger choices inside the airport terminal. It is intended to improve the current models and test more factors and interactions that will account for what the passengers:

- feel (time)
- are (SDC)
- do (activity related aspects)
- see (signage, space configuration)
- perceive (confusion, space configuration)

Passenger choices can be further explored by adding the aforementioned discretionary activities that this airport offers. This will be the first priority in our future work. However, more approaches could be followed. Expanding the model to an upper level that could capture all the possible choices of the passengers upon their arrival at the airport until their arrival at the security control area, could be useful in passenger flow management. It would be expected that airport operators could extrapolate strategies/policies to direct the passengers to areas that they desire depending on passenger type, the time of the day or any other criterion is regarded as important for the case study airport. Appropriate model specifications could also provide insights to the managers of the airport in terms of revenue planning.

It would also be interesting to perform the same process for the choices of the passengers after passing the security control process. This would allow us to tentatively make conclusions for the factors that affect the passengers before and after security, which is the separating "line" of the landside and airside of an airport. Additionally, in terms of data, in the future, actual quantified flows would allow an accurate comparison of space syntax results and movement patterns. They would also enable us judge passenger distributions inside the building. Such analysis could be accomplished with the provision and exploitation of camera data and pedestrian trajectories.

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