Abstract

Airports are transport facilities that accommodate both processes related to the passenger air-trip and usually many non-aeronautical activities. This paper aims to explain and predict passenger activity choices at the airport terminal area before the security control. Lisbon Portela airport was used as a case study and pertinent data was collected at the airport by the authors. A multinomial Logit model was estimated to explain passengers’ choices regarding activities in the terminal and more specifically, whether passengers choose to perform only aeronautical activities before the security checkpoint or they choose both aeronautical and non-aeronautical activities. Aspects such as travel frequency, travelling for business, performing the check-in online and having planned the activities before arriving at the airport influence the passengers towards not performing discretionary activities before security. Passengers travelling to international destinations while not living in the city of the airport and passengers arriving at the airport accompanied by friends or relatives were more likely to use the non-aeronautical areas. When testing an increase in the proportion of the passengers who complete the check-in online from 30% to 70%, we found that the share of the passengers who perform only aeronautical activities would increase from 47% to 53%. This modelling approach can be used when analyzing scenarios of the airport’s operations in the future considering changes in passengers’ behavior.

Keywords: passenger activity choices, airport terminal, discrete choice modeling, Portela airport, Lisbon

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1. Introduction

Airport buildings are complex transport facilities that accommodate multiple activities that primarily serve the air travel and secondarily the passenger free time while in terminal. The travel experience in the airport terminal includes all the required processes that take place in the building, require the passenger participation, ensure the preparation of the passengers for their air trip and cover their free time. Before boarding passengers have to pass through 4 different processes: check-in, security, immigration and gate check. In between these aeronautical processes, they spend their available time in other activities which are not part of their air-trip.

Non-aeronautical activities have been gaining momentum for more than 10 years because of their high contribution to airports’ revenues (Graham, 2009). However, not all of the passengers desire to engage themselves to the same type of discretionary activities; preferences differ according to passenger characteristics and the airport type. It has also been shown that at existing airports offering non-aeronautical activities before security may also alleviate long queues at the security checkpoint (Kalakou et al. 2015). After understanding when (and where) the passengers spend their time and after exploring passenger preferences over non-aeronautical services, airport managers can better plan facilities to match passengers’ needs and efficiently allocate the terminal space.

Current practices show that passenger profiles define the types of the offered discretionary activities at an airport terminal. Hub airports usually offer a wide range of non-aeronautical activities to their passengers. For this type of airports, the passenger experience is of vital importance since many passengers spend their transit time in-between their long-haul flights. For instance, Frankfurt airport is regarded as a family friendly airport but it also offers many types of services targeting to business travelers. It is also indicative that at these airports, passengers can find specialized areas such as wellness institutes, prayer rooms, casinos or entertaining areas. Heathrow’s “Plaza Premium Lounge Arrivals” offers a private place where passengers can freshen up with a shower and relax for £25 per person including complimentary food, soft drinks and house alcoholic beverages. Smaller hubs such as Vancouver also cater a lot for offering diverse facilities such as medical and wellness services, while sport screens are offered both before and after security close to beverage areas for the entertainment of the passengers. Conference areas, VIP lounges and special passenger services, such as laundry, are some of the services often met at business airports. In all the cases, space allocation to different activities in a terminal is important as it affects both the passenger experience and ultimately the airport’s revenues. Retail arrangements should follow passenger flows and preferences since better usability of a system can be achieved through a user-centred approach which integrates the user’s perspective into a system (Maguire, 2001).

Ma and Yarlagadda (2012) categorized non-aeronautical activities into ten discrete groups serving different purposes (information service, cash service, major relief, basic relaxation, social connectivity, fast self-service, shops, tax return and religion-related service) in order to use them as variables in a (passenger) agent-based model. They estimated the conditional probabilities of performing each activity through the use of Bayesian networks. Popovic et al (2010) classified airport discretionary activities into 2 types: the first one was related to optional travel-related activities such as currency exchange and the second one to non-travel activities such as shopping. They also identified 4 activity patterns: group, concurrent, individual activities and activities related to the personal belongings of the passengers. Research related to modeling passenger activities has been conducted by Hoogendoorn and Bovy (2004) who developed and applied an activity-based model including route choices in order to model passenger choices inside Amsterdam Schiphol airport. Canca et al (2013) developed a discrete-time, macroscopic attraction-based simulation model, which also included destination attraction, location and the route choices. Liu et al (2014) focused on passenger activity scheduling; they developed a nested model for the discretionary passenger activities with the following nests: most frequent, less frequent, time killing and shopping activity, and identified that some of the aspects that play a role in the choice of where and what type of activity to perform were: the age, the frequency of travel, the group size and the gender.

Following a bottom-up passenger-centric approach this paper intends to explain and predict passenger activity choices at the terminal area before the security control. We estimated a discrete choice model which reveals the factors that affect the passenger choice of performing or not performing discretionary activities before security. Such a model could later be used to forecast changes in passenger choices under different future scenarios such as changes in the percentage of the passengers who perform the check-in online. The scope of this paper is restricted to
medium-sized airports that have been planned with the traditional “hourglass” shape that implies the separation of the airport into two distinct areas: before and after the security checkpoint.

When studying non-aeronautical activities in terminal, up to date, the literature has mainly tackled the issue of identifying the factors that lead to revenue maximization (Castillo-Manzano, 2010; Saraswati and Hanaoka, 2012). However, we don’t aim studying airport revenues neither creating efficient strategies that generate the passenger need for more activities. The focus is rather shifted towards revealing which the characteristics of the passengers are that influence them to perform activities before the security control. In fact, the characteristics affecting passenger’s decision on whether to spend time before or after security have not been studied in the past. Exploration and decomposition of passenger activity choices can potentially trigger a new approach to airport planning and, possibly, enhance airport revenues. Passengers might restrict their choices in aeronautical activities or perform few or many non-aeronautical activities. Identifying the characteristics of the passengers who choose different activity-sets while in airport could assist prudent airport planners who could combine the results of discrete choice models with proper marketing analysis.

In the context of this paper, Lisbon Portela airport is used as a case study and pertinent data was collected at the airport by the authors. A revealed preference survey of about 500 respondents was conducted at Portela’s Terminal 1, covering questions grouped in 5 categories with respect to the time before flying, personal information, air trip information, activities (both aeronautical and non-aeronautical) and wayfinding aspects the building. We believe that activity behavior in a terminal is a combination of activity and route-choice analysis but only when studying large and complicated environments such as hub airport terminals or central railway stations. Since, we don’t consider the terminal area that we study as such a complicated area, we restrict our study in activity choices and we estimated a multinomial Logit model that explains passengers’ choices regarding activities in the terminal and more specifically, whether passengers choose to perform only aeronautical activities before the security checkpoint or they choose both aeronautical and non-aeronautical activities. Results suggest that propensity for doing non-aeronautical activities before security can be expected based on the combination of personal and trip characteristics, while attributes of buildings are less influential.

The remainder of the paper is organized as follows: Section 2 describes the survey we conducted at Lisbon airport in order to collect data for our modeling process. Thereafter, Section 3 presents the estimation of our final model over the choice of the passengers to conduct or not conduct discretionary activities before the security and the use of the model to forecast the choices of the passengers when we assume that they all perform the check-in online is presented. Finally, Section 4 discusses the implications we derived from the model’s estimation and use.

2. Passenger activity behavior at Lisbon Portela airport

Portugal’s biggest airport, Lisbon Portela airport, is used as a case study. It has two runways and two passenger buildings. In 2014 the total number of served passengers was around 18 million. Before the security control area, passengers can visit beverage areas, a retail and a lounge area, or wait at benches located at different parts of the airport. A revealed preference survey was conducted to collect information on the activities of the passengers inside the terminal since their arrival at the airport until passing the security control area. Passengers participating in special frequent-flyer programs were excluded as they were served at special security lanes. Likewise, passengers travelling with low-cost carriers were excluded because they were served at a dedicated low-cost terminal. Passengers with restricted mobility and passengers travelling with babies were also excluded as they use dedicated areas. The data collection took place during the first week of March 2014 from 10am to 9pm. The passengers were randomly asked to participate at one of the following steps of their travel experience (before security): at the locations of discretionary activities, while walking around or at the security control area.

We assume that the passenger choice to spend time at discretionary activities before security is influenced by aspects related to time, passengers’ personal socio-demographic characteristics, trip details, passengers’ activity plans and passengers’ perception over the building’s configuration. Hence, the survey was structured in 5 parts that concerned the aforementioned areas:

1. **Time**: The passengers were asked to provide the time of flight departure 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.

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

3. **Air trip information**: Pertinent air trip information concerned the following items: airline, destination, number of baggage, mode of check-in and mode of arrival at the airport. 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.

4. **Activities**: Passengers were asked to report the activities they performed inside the airport since they arrive at the terminal until reaching the security control area. Such information indicates which activities passengers decide to perform before going to the security area. As such, we could identify the main attractors that make passengers divert from their next aeronautical destination (the security control area).

5. **Wayfinding**: Issues relevant to the easiness to move inside the building were collected here. 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.

Table 1 presents the preferences of the passengers for different activity sets actually performed in the terminal before the security checkpoint. We note that each set of activities could be presented with a different sequence and that this aspect was not relevant for the present analysis. The majority of the passengers (35.2%) used the check-in area and chose to perform 1 discretionary activity that could either be a visit to a beverage area, a retail area or the lounge area. The second biggest group of passengers (33.8%) restricted its activities to the aeronautical tasks related to their trip. Almost 1 out of 8 (12.9%) passengers went directly to the security control after arriving at the airport. In general, 47% of the passengers conducted only aeronautical activities before the security and 53% chose to do discretionary activities too.

| Activity-set description | Passenger preference |
|--------------------------|----------------------|
| Security                 | 12.9%                |
| Security / Check-in      | 33.8%                |
| Security / Beverage      | 5.5%                 |
| Security / Retail        | 0.2%                 |
| Security / Lounge        | 1.9%                 |
| Security / Check-in / Beverage | 28.5% |
| Security / Check-in / Retail | 1.9%  |
| Security / Check-in / Lounge | 4.7%  |
| Security / Check-in / Beverage / Retail | 3.4% |
| Security / Check-in / Beverage / Lounge | 2.6% |
| Security / Check-in / Retail / Lounge | 0.4% |
| Security / Beverage / Retail | 1.9%  |
| Security / Beverage / Lounge | 0.9%  |
| Security / Retail / Lounge | 0.2%  |
| Security / Check-in / Beverage / Retail / Lounge | 0.8% |
| Security / Beverage / Retail / Lounge | 0.4% |
Figures 1a, 1b, 2, 3a, 3b and 4 present the statistics of the collected data, categorized according to the passenger choice to spend time before security to only aeronautical activities or share the available time between aeronautical and discretionary activities. Figure 1a gives information over the gender, nationality, residency and travel frequency.

In Figure 1b we see the percentage of passengers who travelled alone, for which purpose they travelled, how many baggage they checked-in and how they checked-in. Figure 2 presents information about the destination type of the passenger, how many of them travelled during the weekend and in morning hours, how many were on a transfer, felt stress or fear, how many performed the check-in 90, 75, 60 or less than 60 min before flight departure and how many arrived at the security and the gate at specific time intervals before flight departure. Figure 3a shows statistics over how many passengers followed the signs, felt familiar with the airport configuration, were first time users, used landmarks, felt confused and how they evaluated their wayfinding (Wf) experience. Figure 3b presents the arrival mode and Figure 4 activity statistics for the area before the security; additionally, it shows how many passengers went to the gate and then back to other activities and how many went to board immediately after security. We observe high variability between the two choices for the following aspects: number of baggage, check-in mode (both in Fig. 1b); preference to visit shops after the security control (not shown here); whether the passenger arrives alone
(Fig. 3b); if she goes directly to gate after the security control or intends to check the location of the gate and then decide if she will return to perform a discretionary activity (Fig. 4).

![Fig. 3. (a) Building-related characteristics; (b) Arrival-related characteristics.](image)

![Fig. 4. Post-security-related characteristics.](image)

We calculated the correlations among all the afore-presented variables and the results did not show the existence of strong correlations. Not surprisingly, the highest values were reported for Portuguese passengers who are familiar with the airport (0.44). Also we observe that there is some correlation between passengers being Portuguese but not living in the Lisbon area (-0.41), since Portela is the main Portuguese airport. Finally, passengers who arrive alone were inversely correlated with arriving by car (-0.43).

In the next section, we present a model that explains passengers’ behaviour with respect to performing only aeronautical activities before passing the security control or devoting time both to aeronautical and discretionary activities.

### 3. Modeling passenger activity preferences

Discrete choice models are used to explain a decision maker’s choice over a defined set of alternatives. Their 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 $\varepsilon$ that captures the errors in the model outcome coming from several possible sources: unobserved alternative attributes, unobserved individual characteristics, measurement errors or 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.

3.1. Modeling passenger activity preferences at the airport

For the modeling process we used Biogeme software (Bierlaire, 2003). Initially, we attempted to estimate a model with all the 16 activity-sets available. Only departing passenger observations were used for the estimation of the model and the sequence of activities was not taken into account. However, the very limited number of observations for some of the sets did not allow the estimation and since we lacked real data over the population we could not use weights. Thereafter, we grouped the choices to six sets comprising the following alternatives: only security; Security/Check-in; Security/Check-in/1 Discretionary activity; Security/Check-in/2 Discretionary activities; Security/1 Discretionary activity; Security/2 Discretionary; Security/3 Discretionary; and Security/All. We could not calibrate this model specification because the variable “baggage check-in” was dominating (i.e., excluding) all other possible explanatory variables. In fact, more variables did lead to models with statistically significant variables and meaningful signs, but that were failing to improve the log-likelihood test. Finally, we decided to explore the choice of the passengers either to perform aeronautical activities before passing the security control, only, or both aeronautical and non-aeronautical.

3.2. Model estimation

Only characteristics of the decision-makers were used for the estimation of the model. Our a priori assumptions were that the choice of spending the available time to only aeronautical activities is positively affected by the following attributes: traveling frequently, traveling for business, arriving at the airport late, arriving at the airport alone, traveling alone, traveling to an international destination, being familiar with the airport, being a resident of the area of Lisbon, being a young traveler, arriving by car and performing the check-in online. Since there are only two alternatives (performing only aeronautical (“aero”) or both aeronautical and non-aeronautical (“non-aero”) activities), the specification of the non-aero alternative includes only the Alternative Specific Constant (ASC) which is fixed. The equivalent ASC is included in the “aero” alternative utility with the parameters related to all selected variables. 80% of the dataset was used for the estimation of the model. After setting a first base model that included arrival time, travel frequency and online check-in, we tested different specifications ending with the final model presented in Table 2, by comparing respective log-likelihoods and adjusted $\rho$-squares. The table includes the parameters’ names in column 1. Column 2 describes the parameters and column 3 presents their values and the corresponding significance levels. The log-likelihood that we obtained for this model is -171.291 and the value for the adjusted $\rho$-square is 0.239. Among the variables and the interaction among variables used to estimate the model, we did not find correlations higher than 0.26, meaning that they are fairly independent.

The signs of the estimated parameter values were the expected ones. The ASC of the “aero” option was insignificant, implying that the variables included in the model can adequately explain the choices of the passengers.
As expected, the passengers who do not reside in the Lisbon area and who were traveling to international destinations (\( \beta_{\text{interrNonRes}} \)) are more likely to spend time on non-aeronautical activities before passing through the security control. The frequency of travel (\( \beta_{\text{freq}} \)) was found to affect passenger choices; the more often a passenger travels the more likely she is to restrict herself to aeronautical activities. These outcomes are reasonable since international travelers need to pass through a second passport control checkpoint after security and frequent flyers usually choose a simplified travel experience.

Table 2. Model estimation

| Parameter name     | Parameter description                                                                 | Parameter Value |
|--------------------|---------------------------------------------------------------------------------------|-----------------|
| ASC_aero           |                                                                                       | 0.526           |
| \( \beta_{\text{CfamCom}} \) | 1 if the passenger arrives accompanied by non-passengers by a family or friend car   | 1.06 *          |
| \( \beta_{\text{freq}} \) | how frequently the passenger travels (times/year)                                     | 0.216 **        |
| \( \beta_{\text{accompanied}} \) | 1 if the passenger arrives accompanied by non-passengers                              | -1.31 ***       |
| \( \beta_{\text{arrivalTime_SC}} \) | arrival time before flight departure (in minutes)                                      | -0.888 ***      |
| \( \beta_{\text{business}} \) | 1 if the passenger travels for business purposes                                       | 0.702 ***       |
| \( \beta_{\text{check90FamSch}} \) | 1 if the passenger is familiar with the airport, travels to Schengen destinations and performs the check-in 60 to 90 min before departure | -0.908 ***      |
| \( \beta_{\text{onlineCI}} \) | 1 if the passenger performs the check-in online                                        | 0.955 ***       |
| \( \beta_{\text{firstStrCI}} \) | 1 if the passenger is a first time user, stressed to complete all activities and completes the check-in at a counter | 3.87 ***        |
| \( \beta_{\text{gate}} \) | 1 if the passenger after security goes to gate and then decides what to do             | -0.734 ***      |
| \( \beta_{\text{gateArrival}} \) | 1 if the passenger arrives at gate between 30 and 60 min before departure            | 0.935 ***       |
| \( \beta_{\text{group}} \) | the number of passengers travelling with                                               | 0.503 **        |
| \( \beta_{\text{interrNonRes}} \) | 1 if the passenger travels to an international destination and does not live in Lisbon | -1.29 ***       |
| \( \beta_{\text{plannedAct}} \) | 1 if the passenger has planned his activities before going to the airport            | 0.716 ***       |
| \( \beta_{\text{weekendBag}} \) | 1 if the passenger travels during the weekend with baggage                            | 0.875 **        |

Notes: * Significant at 10%; ** Significant at 5%; *** Significant at 1%; LL = -171.291; \( \rho \)-square = 0.239

Some trip, flight and building-related variables were found to be statistically significant and were used to explain passenger choices both individually and in interaction with each other. The aspects affecting passenger choices per se were the following: online-check-in, business trip, group of passengers and time that the passenger wants to reach his gate. Performing the check-in online (\( \beta_{\text{onlineCI}} \)) and traveling for business purposes (\( \beta_{\text{business}} \)) contributed to choosing to spend time only to aeronautical activities. Both results were expected considering the limited available time of business travelers and the concept of fast-services that follows the choice of checking-in online; online check-in is part of the effort to simplify airport business and favors the passengers who wish to avoid long queues at the check-in area. In addition, the bigger the number of the passengers who travel with the passenger (\( \beta_{\text{group}} \)), the more likely she is to pass the security control immediately after completing the aeronautical tasks. This can be explained by the fact that the more the passengers that have to pass through the security control the higher the uncertainty of the time required to leave the security checkpoint. Regarding post-security behavior, those passengers who revealed that they wanted to be at their gate 30-60 minutes before flight departure (\( \beta_{\text{gateArrival}} \)) were also more likely to do only trip-related activities before security. In terms of interacting variables, first-time users of this airport who conduct the check-in at a counter and who feel stress to complete all their obligations until reaching the gate (\( \beta_{\text{firstStrCI}} \)) are also more likely to perform aeronautical activities before security, only. Once again, it seems that the pending security control imposes pressure to the passengers to pass the security area as soon as possible. Having baggage was also found to affect passenger behavior on weekend-flights (\( \beta_{\text{weekendBag}} \)) by favoring the choice of performing only aeronautical activities before security. On the contrary, passenger who are familiar with the airport
terminal, fly to Schengen destinations ($\beta_{\text{check90FamSch}}$) and completed the check-in 60-90 minutes before flight
departure, are more likely to perform both aeronautical and discretionary activities before security.

In relation to the arrival of the passengers at the airport ($\beta_{\text{arrivalTime_SC}}$), the earlier the passengers arrive the more
likely they are to perform non-aeronautical activities. The same applies when the passengers arrive at the airport
with people who are not traveling with them ($\beta_{\text{accompanied}}$). However, when considering the mode of arrival, when the
passengers are accompanied at the airport and arrive with a family car ($\beta_{\text{CfamCom}}$), they are more likely to restrict
themselves to aeronautical activities. This might be explained by the fact that accompanying people need to continue
to their daily obligations and activities since they are using their car. Finally, considering the time-plan while in
terminal, passengers who have planned their activities before arriving at the airport ($\beta_{\text{plannedAct}}$) were found to be
more prone to perform only aeronautical tasks before passing the security control. Conversely, the passengers who
revealed that after security they would first check where their gate is located and then they would decide what they
would do ($\beta_{\text{gate}}$), they did perform discretionary activities before the security, showing a higher propensity for non-
aeronautical activities.

After estimating the model, we used 20% of the dataset for the validation of the estimated model. Figures 5a and
5b show that 70% of the observations were correctly forecasted with a probability higher than 50%. More precisely,
the probability that the real choice coincides with the model prediction is higher than 75% for almost 40% of the
passengers.

Having tested the forecasting ability of the model, we analyzed a scenario where the passengers who complete
the check-in online would increase from a share of 30% to 70% of total travellers. In order to test this scenario, we
created 10 new datasets for which we randomly changed the check-in mode from counter to online check-in. The
forecasts of the model gave stable results and showed that the share of the passengers who perform only aeronautical
activities will increase from 47% to 53% in face of that variation. This change in shares implies that the terminal
area before security will become under-used as counter check-in decreases (as more travellers are doing check-in
online before heading the airport). As such, the airport managers could use this redundant area for alternative
activities. This presented analysis illustrates the potential utility of this modeling approach of passenger behavior, in
order to estimate area requirements in face of foreseeable changes of travellers’ characteristics. In the next step of
our research, additional future implications for terminal area requirements will be analyzed by considering, for
instance, more changes in the passenger profiles such as the increase of business travelers and changes in the
proportion of Schengen and international flights. We also consider important the effect of the fact that in the near
future many passengers will have already planned their activities before arriving at the airport due to the high
availability of mobile applications that allow them to pre-order their lunch, their retail purchases etc. Furthermore, by coupling these models with simulation models, we could estimate how many people would need to use each area of the terminal before security and check for the implications on terminal requirements on each activity type.

4. Conclusions

In this paper, we proposed that we can analyze in parallel passenger and airport characteristics in order to explore the passengers choices while in terminal. The innovation of the methodology is that we aimed to delineate the passenger characteristics that affect their choices on whether to choose to perform discretionary activities before the security control besides aeronautical ones. It was shown that aspects such as travel frequency, travelling for business, performing the check-in online and having planned the activities before arriving at the airport influence the passengers in their choice to not perform discretionary activities before security. The aspects that favoured non-aeronautical activities before security were travelling to international destinations while not living in the city of the airport and arriving at the airport accompanied by people who do not travel. When increasing the proportion of the passengers who perform the check-in online from 30% to 70% we found that the share of the passengers who perform only aeronautical activities before security will increase from 47% to 53%. By modelling passengers’ activities choices, we contribute to better understanding the passenger behaviour and experience in the airport terminal. We believe that when combining such models with other marketing methods, this methodological concept can be used as a proactive alternative in airport planning, operations and commercialization strategies.

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