THE BOEING 737 MAX RETURN TO SERVICE AND COMPETITION:

HOW PASSENGERS' PREFERENCES WOULD CHANGE DUE TO THE LATENT FEAR OF FLYING

ALENCAR BRAVO; DARLI RODRIGUES VIEIRA
UNIVERSITY OF QUEBEC IN TROIS-RIVIÈRES, CANADA

GERALDO FERRER
NAVAL POSTGRADUATE SCHOOL, MONTEREY-CA, US

Keywords: fear of flying; airplane; choice; flight accidents; air ticket; passenger behavior; preference; Boeing; Airbus; Embraer; Sukhoi

Abstract: Fear of flying has no direct relationship with actual airline or aircraft safety. In our modern and information-filled era, it is surprising that many people are still afraid of flying. For those afraid of flying, the choice of air ticket and the related airplane is expected to be an important issue. This article uses a methodology for simulating the experience of purchasing unlabeled airline tickets to investigate whether individuals who are afraid of flying would unconsciously change their choice depending on the ticket parameters. The Boeing 737 MAX, that became notorious by the extensive media covering of its grounding due to two recent accidents, could be randomly assigned to the flight tickets to simulate a return to service. This aircraft was compared with other eight competing alternatives; the results demonstrate that when it returns to service, preference for this aircraft will probably be low, comparable to that for competing airplanes that are less known to the North American public. Nonetheless, Boeing products as a whole continue to instill a sense of safety and trust in those afraid of flying.

1. INTRODUCTION

The airplane was a revolutionary creation, and today, it is one of the safest means of transportation (Braithwaite, 2017). Aviation standards are set much higher than those of several other industries (Sengupta, Donekal, & Mathur, 2016; Zhang & Xiang, 2013). Efforts to strengthen security have borne fruit: it is numerically safer to choose air than any other form of transport. **Figure 1** compares different types of transport, ranging from walking to riding a bicycle, driving a car, taking a bus, or flying on an airplane. The data show deaths in the United States in 2018 (dark bar) in descending order and the probabilities of a person dying when using each form of transportation as the ratio between deaths for that mode of transportation and the total population then divided by the average life expectancy. This calculation considers the population and life expectancy of the United States in 2018.

For example, according to the ranking in **Figure 1**, a person is exponentially less likely to die as a passenger in a heavy transport vehicle than on a bicycle. Likewise, it is exponentially less common to die on a bus than on an animal-drawn vehicle. Air transport, in turn, is exponentially safer than transport by bus —so much so that estimating the probability is not recommended as the number of deaths is lower than 20/year.

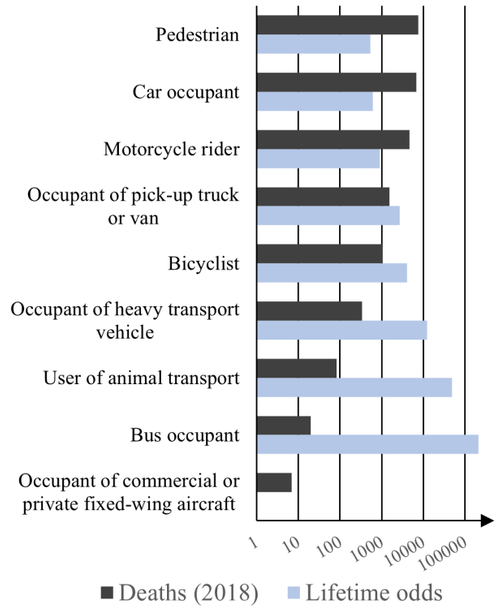

Figure 1: Number of deaths in the United States (2018) and the inverse lifetime odds of dying when using different transportation modes (National Safety Council (NSC), 2020)

In summary, traveling by plane is one of the safest options for protecting our physical integrity. However, in general, many passengers continue to suffer from a strong fear of flying (Gerwen & Koopmans, 2018). Because of this fear, some people do not fly, and others restrict flying to an absolute minimum and feel considerable discomfort before and/or during each flight. A third group feels mild or moderate apprehension such that, even if they do not avoid flying, it remains an unpleasant experience (Carl et al., 2019; Foreman, Bor, & Van Gerwen, 2016).

Statistical information demonstrating the reliability of air transport is more broadly available than ever. In 2017, there were only 59 deaths due to air traffic worldwide, but there have been some tragic incidents in recent years (Forbes, 2019). The first major event occurred in October 2018, when a flight by the Indonesian airline Lion Air crashed and killed 189 people. The second, in March 2019, involved Ethiopian Airlines and killed 157 people (NYT, 2019). These two incidents changed the statistics in two consecutive years. Since the second accident, the model of plane involved in the two accidents, the Boeing 737 MAX (B73M), was grounded and prohibited from flying by practically all air transport regulatory agencies worldwide. This generation of the famous B737 suffered a reputation crisis (Cruz & Dias, 2020).

The main difference between the B73M and its previous version is that the B73M has larger and more efficient engines. This plane is Boeing's answer to the A320 NEO, which is a version of the famed A320 but also with larger and more efficient engines (Temesgen, 2019). The issue with the 737 MAX is that there was insufficient space between the engine and the pavement to mount the engines in the same position underneath the wings as previous 737 models while also preserving the regulated safety clearance. The manufacturer could raise the overall height of the plane, but this would have a negative consequence for airlines who operate the previous model, as they would not be able to operate both versions of the plane in the same airports as if they were the same plane (Wendel, 2019). Therefore, the decision was made to position the plane's engine further forward and higher than it had been on the previous model. This guaranteed airport operation similar to that of the previous model, but it changed the flight characteristics of the aircraft, notably at takeoff (Johnston & Harris, 2019). Different flight characteristics require different pilot training. To preserve the same pilot certification, Boeing installed a system called MCAS (Maneuvering Characteristics Augmentation System), with the autonomous ability to adjust the trim on the aircraft. The system is considered the element responsible for the two disasters and has been the main target of the recertification process (Bergstra & Burgess, 2019).

These events attracted significant media attention. The MCAS system, Boeing and various regulatory bodies have been the targets of much criticism (Cutler, 2019), and at the time of writing this article, the plane has yet to obtain approval to fly again. This presents a big opportunity for competitors of the North American company, and it is expected that it will take time for the company to recover from the forced production and delivery interruption (Cameron & Wall, 2019).

Following the B73M events, few studies have focused on how the general fear of flying affects passenger ticket-buying behavior. This article proposes a methodology for simulating the air ticket purchasing experience to determine how fear of flying affects competition between different aircraft.

This article is organized as follows. First, there is a review of the relevant literature, focusing on studies concerning the fear of flying. Second, contextualization is provided to explain the choice of airplanes in this study and their main characteristics. Third, the methodology is explained, followed by the results and the discussion. Finally, we present the conclusion.

2. LITERATURE REVIEW

Flying is essential for the economy. The flight industry supports other industries, such as tourism (Dimitrios, John, & Maria, 2017), and a wide range of activities. It is a driving force of new business and social integration (Pappachan & Koshy, 2018).

As discussed in the previous section, fear of flying (FoF) is quite common among passengers of civilian aircraft. It can profoundly affect an individual, as recorded in the Diagnostic and Statistical Manual for Mental Disorders (American Psychiatric Association, 2013). FoF is part of the large family of phobia-like conditions specifically linked to flying called aviophobia (Shiban et al., 2017).

A large share of the population suffers from some degree of FoF (Ekeberg, Fauske, & Berg-Hansen, 2014; Mühlberger, Weik, Pauli, & Wiedemann, 2006), and they may take sedatives or join workshops for individuals with high FoF to address this problem (Gilbert & Wong, 2002). However, FoF has no direct relationship with the risk presented by the airline or the aircraft. Some airlines are aware of passengers' FoF and take nondisruptive measures to alleviate the condition (Fleischer, Tchetchik, & Toledo, 2012).

A striking point in FoF history was the period after the terrorist attacks of September 11, 2001. In this historical episode, four airplanes were hijacked on the same day, and three of them were crashed into office buildings, killing several thousand (the fourth plane fell on an empty field). Because of these events, many people who previously were not afraid of flying developed strong flight anxiety, and the civil air transport industry suffered significant ticket sales reduction (The World Bank, 2019). For example, in the four months after the incidents, there was an increase of 50% to 80% in the number of cancelations in Germany by passengers who became sick before boarding, although we cannot specifically link this to the terrorist acts (Mühlberger, Alpers, & Pauli, 2005). Passengers who suffer panic before flying do not seem to focus on a specific terrorist event, but they experience, among other causes, a general fear of terrorism (Ekeberg et al., 2014).

Passengers' FoF level is thought to influence the direction of their choices. FoF does not have socioeconomic boundaries. Millions around the world refuse to fly, and many more are scared when they fly (Tyrinopoulos & Antoniou, 2020). There are reports of airlines' difficulties in addressing this challenge and determining the visible safety conditions for passengers, but it is difficult to infer their effect on ticket decisions (Barnett, 2020).

FoF has a somewhat constant baseline (Mühlberger, Herrmann, Wiedemann, Ellgring, & Pauli, 2001), and the number of passengers who prefer service and comfort flights, as well as flight characteristics that mitigate fear, is not negligible (Bravo & Vieira, 2019). Batouei et al. (Batouei, Iranmanesh, Nikbin, & Hyun, 2019) tried to establish whether certain individual features increased the likelihood of ceasing to fly after 9/11/01 and concluded that a baseline FoF affects the decision to stop flying.

Airlines and manufacturers use many strategies to mitigate the FoF effects related to ticket choices. One example is green marketing. Many studies have been performed to verify the possibility of increasing aircraft eco-friendliness to achieve this purpose (Budd & Budd, 2013; Vieira & Bravo, 2016a, 2016b).

The green aspect can create a feeling of responsibility while simultaneously relieving the customer of a certain environmental guilt (Baer, 2019). Among other things, green marketing may cause an increase in overall customer satisfaction with civil air transport, which is important because satisfaction is an important aspect in the repeated choice of an airline (Bravo & Vieira, 2019).

The satisfaction of flying on an airplane is not only based on a greener engine, which might lead someone to choose one particular ticket, but also on other factors. Satisfaction is a complex factor, being a cluster of numerous variables including image, which is itself a complex factor. For this reason, many airlines devote a large part of their budget to marketing campaigns, trying to appeal to customers' emotional side. This investment is ongoing and usually well justified. Efforts to improve the image of an airline usually result in more revenue in the form of increased demand (Forgas, Moliner, Sánchez, & Palau, 2010).

Safety factors are important for customers, who make choices in conjunction with their internal beliefs associated with fear (Bravo & Vieira, 2019). Treating trust as the opposite of fear, the ticket choice problem is largely modeled in the literature using trust (in the airline) rather than FoF (Akamavi, Mohamed, Pellmann, & Xu, 2015; Han, Yu, Chua, Lee, & Kim, 2019).

In addition to the financial gains that airlines may observe from increased revenue due to positive marketing, it is possible that they also profit from recovering lost travelers with high FoF (Shahrabani & Regev, 2019). However, there are very few such models in the literature because only the airline can determine whether the risk of recapturing the lost traveler is acceptable and how much marketing effort should be invested in this task.

It is also possible that FoF travelers with high FoF spend more on their flights, which can be an important income opportunity for airlines. Under this reasoning, they are less sensitive to price changes due to the value they attach to specific ticket qualities. If the passenger is particularly attracted to the perceived safety of a specific aircraft, he or she might be willing to pay more for that ticket.

Some studies evaluate flying sickness treatments using modern technologies, such as virtual reality (Czerniak et al., 2016; Klein, 2000; Price, Anderson, & Rothbaum, 2008). This is a valid research technique and valuable for understanding the psyche associated with this emotional phenomenon. This approach allows results to be obtained for a fraction of the cost of paying for actual flights (Boyd & Hart, 2016; Rothbaum, Hodges, Smith, Lee, & Price, 2000). In addition to savings, the quality of immersion and the intersection between virtual and actual reality are significant. The use of this technology has proven effective in significantly reducing FoF anxiety. In the current context, with multiple choices available to customers, air transport companies and manufacturers could consider using this technology to reduce FoF anxiety.

Globalization and liberalization contribute to expanding the availability of carriers and aircraft, and there has been an increase in the number of alternatives for getting from one point to another. Therefore, the choice of airline network becomes important. Some companies prefer a point-to-point network model, in which all cities are connected to each other with nonstop flights (Alderighi, Cento, Nijkamp, & Rietveld, 2007), as opposed to the hub-and-spoke model, with which an airline expands the connection between a large number of airports, the ends of the spokes, by making stopovers in a few major airports, the hubs (Alderighi, Cento, Nijkamp, & Rietveld, 2005). The hub-and-spoke model implies traveling from point A to point B will usually require at least one stopover at a hub; this exacerbates FoF, which is prevalent at takeoff or landings (van Gerwen, 2017).

FoF is a problem that has persisted since commercial flights began. Air travelers who fear traveling are a missed opportunity for airlines in a dynamic, competitive environment, and thus present implications for future study and policy growth. Few studies have taken into account the multidimensional aspect of ticket choice, and those that tried (Fleischer et al., 2012) focused on the airline's viewpoint.

This article contributes to understanding how travelers make flight choice decisions considering aircraft, airline and price alternatives. We use randomized, fictitious plane tickets that are converted into flight choice probabilities. This enables us to observe how new and traditional aircraft from different manufacturers affect travelers' ticket purchasing decisions, colored by each traveler's FoF.

3 PARAMETERS AND METHODOLOGY

An airplane ticket contains much important information in addition to the destination and the boarding time. We consider three parameters of the ticket: the company that provides the service, the ticket price and the aircraft assigned to the flight. We simulate tickets to two possible destinations for travelers departing from Montreal. The first destination is Fort Lauderdale, an important tourist destination because it offers many vacation activities for those aiming to avoid the Canadian winter (Desrosiers-Lauzon, 2009). The other destination included is Mexico City, also known as a tourist destination. The Canadian tourists who disembark there are also fleeing the cold winter during the holidays (Coates, Healy, & Morrison, 2002); they are called "snowbirds" because they maintain the habit of fleeing the winter by traveling south every year. We consider tourist travel instead of business travel because tourists usually select their own tickets and tend to be sensitive to ticket price differences.

We considered tickets issued by three major Canadian airlines: Air Canada, WestJet and Sunwing Airlines; these trips out of Montreal are consistent with their network. Tickets were priced from Can$ 600 to Can$ 1400 at intervals of Can$ 100.

Nine airplane models were included in the study. The first considered was the Boeing 777, which is an airplane easily recognized by the public and used by many airlines for transatlantic and transpacific flight, earning it a positive image among the public (Stewart, 2014). The 777 was an innovative aircraft in many respects and was also the first commercial aircraft to be designed entirely on a computer. The B777 has a large, low noise and a two-aisle passenger cabin with capacity for 301 to 368 passengers in typical configurations. It was included in the study as the baseline model due to its immense popularity, as it is one of the signature Boeing aircraft with a positive quality image.

Two versions of the Boeing 737 were included in the study: the B737 NG (B73N) and the B73M. The B737 has a long history. Its fuselage and some of its components were derived from the B727, which provided a large single-aisle cabin with six seats per row. Studies for the first improved version started as early as 1979 and focused on aerodynamic refinements and cockpit modernization (Sherman, 2003). A second update of the B737 was launched in 1984 with improved engines. A collaboration between Boeing and CFM, an association between General Electric and Snecma, resulted in the CFM56 engine. This is a high-bypass ratio turbofan engine with a large inlet diameter, which makes it more economical and powerful (Teketay, 2017). Since the aircraft was not originally designed to receive this engine, there was not adequate clearance between the wing and the runway floor. The solution was to reorganize the engine components and place them on their sides. This gave the fairing an oval shape and a flat base, thus increasing the ground clearance below the engines.

Studies for the B73N began in 1993 and, with the aim of designing a state-of-the-art aircraft with modern technologies and high efficiency. A new instrument panel dominated by computer screens was introduced, inspired by the B777. It includes aerodynamic improvements, including a new wing that increased fuel capacity and improved autonomy a new CFM56 engine, version 7B, with substantial performance improvements (Black, Crossley, & van Seeters, 2012). This is a very popular aircraft today with typical capacities from 108 to 215 passengers.

The B73M project was launched in 2011, with excellent reception from customers, soon becoming the best-selling aircraft in Boeing's history. It presented substantial aerodynamic improvements, including the use of a new double-ended winglet and a modernized cabin, mainly in terms of the information displays. The new engine (LEAP 1-B, made by a consortium of General Electric and Safran Aircraft engines) has an even larger diameter, enabling a major advance in fuel efficiency. Because of the large diameter, it was installed further ahead under the wing to improve ground clearance. The B73M has slightly increased capacity, between 138 and 230 passengers (Teal, 2014).

Three Airbus aircraft were included in the study. In 1984, the project to design the largest competitor to the B737 family was launched, the Airbus 320 (A320). This aircraft was born with a modern base, having as its main differential the fly-by-wire control system, which eliminated the mechanical action between

the pilot and the control surfaces. The A320 is a family of single-aisle twin-engine turbofan aircraft with a capacity range of 132 to 236 passengers across its variants (Petrescu et al., 2017). It has very similar dimensions to the B737, but with a slightly larger internal space, and it is substantially higher off the ground. It has a strong reputation, being the second best-selling aircraft family, behind only the B737.

In 2010, an engine modernization project for the A320 was launched. The NEO - New Engine Option - versions offered the options of LEAP 1A and Pratt & Whitney PW1100G engines along with new and larger winglets. The modernization was slight compared to other cases, and capacity stayed between 140 and 240 passengers (Bewlay, Nag, Suzuki, & Weimer, 2016). Today, both the A320 and A320 NEOs are popular choices among airlines.

Another interesting Airbus aircraft is the A220, developed by the Canadian company Bombardier as the C-series (Buyck, 2018). It is a modern aircraft that targets the 110 to 130 passenger segments. One remarkable characteristic of this plane is its intense use of composite materials, thus guaranteeing the exceptional fuel economy of the modern Pratt & Whitney PW1000G engine. The single-aisle cabin is modern, with an atypical configuration of 2 plus 3 seats per row. Bombardier made massive investments in its development, but delays and cost overruns, combined with limited initial sales, led Bombardier into great financial stress. To guarantee the project's survival, it was transferred to the European rival Airbus, which today owns majority control of the program. Airbus renamed it the A220 and integrated the aircraft into its portfolio. The European giant's support reassured many potential buyers. Coupled with Airbus' large marketing structure, the A220 has since gained reputation and trust (Gomes, 2012).

Although it was not the pioneer in regional aviation, the Brazilian company Embraer revolutionized this market segment with the launch of the E-jet family in 1999 (Machado & Hatakeyama, 2018). This airplane targets the 70 to 110 passenger market with four aircraft models. The two larger models (E190 and E195) have powerful engines derived from the GE-CF34. The E-jets have been successful, with good sales and good reviews, especially among passengers who appreciate the comfort of a single-aisle cabin with four seats per row. They are regional airplanes but are often compared to mainline aircraft. The main representative of the larger E-jets is the E190, which in some cases is considered an alternative to the Airbus and Boeing offers, earning its inclusion in this study.

In 2013, Embraer launched a modernization program for the E-jet family; the term ‘modernization’ is used to reflect the profound design changes. Wings, engines, cabins, cockpits and systems underwent significant updates. In addition to the use of an engine similar to that of the A220, the improvements include a new wing with a high aspect ratio and full fly-by-wire controls (Gomes, Barcellos, & Tucci, 2018). This study includes this new model, the E190-E2 version, which may be fitted for 96 to 114 passengers and is considered to be as efficient as the A220.

Another direct competitor to the E190 is the Russian Sukhoi Superjet 100 (SSJ1). This aircraft entered development in 2000, with a capacity between 87 and 108 passengers in all its variants and a configuration of 2 plus 3 seats per row. It includes fly-by-wire controls, but it does not have the extensive use of composites seen in its rivals. It was built with an international perspective, unlike other Russian commercial aircraft, with many international suppliers, support from Boeing and marketing by the Italian company Aleania Aeronautica (Corallo, De Maggio, & Storelli, 2010). The engine is the result of a joint venture between the French Safran and the Russian NPO Saturn. Despite its focus on the international market, success outside Russia is very limited. It was included in the study because, despite its low international sales, it has similar technical capabilities as the other regional jets.

In summary, for each of the two destinations, we considered three parameters: three service providers (the airlines), nine aircraft, and nine price points. This allowed us to create 3×9^2=273 different tickets for each destination.

To collect the participants' preferences along with an analysis of their FoF, we prepared a questionnaire organized into three sessions. The first section collected demographic information, the second section contained an established instrument with 11 questions to assess the latent participant's FoF according to (Fleischer et al., 2012). The third section proposed nine sets of potential air tickets from which the participants selected their top choice.

In view of the population sampled, we used a mixed logit model (random parameter logit model)(Hensher & Greene, 2003). With this model, the parameters vary from one individual to another, a plausible assumption since people have different levels of experience and FoF.

The data were processed on a computer equipped with an i7-6770 processor with 16 GB of DDR4 RAM using the R language (v.3.6.2) for Windows (32/64 bits). The mlogit package was used to obtain the solution of the mixed logit model assuming the parameters are normally distributed.

4 RESULTS AND DISCUSSION

There were N = 102 people participating in this study, including 62 males and 40 females. In each questionnaire, participants were offered nine sets of nine tickets, and from each set, they were asked to select their preference. Some participants answered multiple questionnaires, but the majority (N = 54) answered just one questionnaire, analyzing and selecting their preference in nine sets. This subset of participants was responsible for 486 choices in this study. **Table 1** details the respondents according to gender and number of choices. The right column shows the size of the final dataset.

Some participants had the opportunity to answer more than one questionnaire version on different days, each time selecting their preferred ticket from each of nine sets of nine tickets, which explains why some participants answered more than nine sets. Some of the participants were excluded from this study because of unusual behavior (e.g., if a participant always selected the third ticket of the set).

Table 2 shows participant demographics according to level of education. Half of the respondents (N = 51) held a college degree. The second largest group (N = 40) had completed their undergraduate education.

Figure 2 shows the distributions of the participants’ ages and their experience with flying (described as the number of completed trips). The average participant age was 29.3 years, with mode = 24 years and median = 26 years. Several participants (N = 15) had never traveled by plane, but most had flown multiple times.

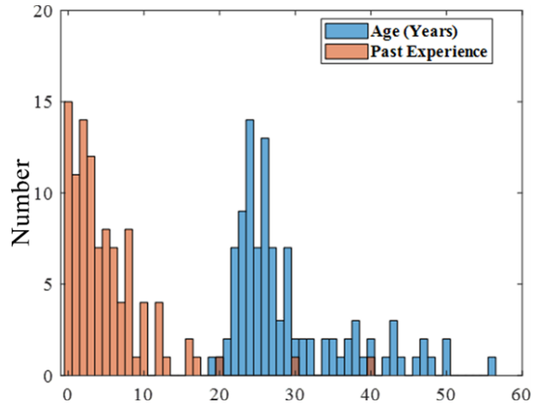

Figure 2: Histogram of participants ages and past air travel experience

Level	Counts	% of Total	Cumulative %
Technical	1	1.0 %	1.0 %
College	7	6.9 %	7.8 %
Undergraduate	40	39.2 %	47.1 %
Graduate	51	50.0 %	97.1 %
Postgraduate	3	2.9 %	100.0 %

Table 2: Level of Education of the Sampled Pool

Number of sets analyzed	Participants			Number of selections		
	Male	*Female*	*Total*	*Male*	*Female*	*Total*
1	3	0	3	3	0	3
2	4	1	5	8	2	10
3	1	0	1	3	0	3
4	1	2	3	4	8	12
5	1	0	1	5	0	5
6	2	1	3	12	6	18
7	1	0	1	7	0	7
9	30	24	54	270	216	486
17	1	0	1	17	0	17
18	5	4	9	90	72	162
21	0	1	1	0	21	21
27	1	1	2	27	27	54
35	6	2	8	210	70	280
36	2	1	3	72	36	108
43	0	1	1	0	43	43
44	3	1	4	132	44	176
53	1	1	2	53	53	106
Total	***62***	***40***	***102***	***913***	***598***	***1511***

Table 1: Summary of the Number of Respondents by Sex and the Number of Selections

Two models were developed, one for the round-trip ticket in the Montreal-Mexico City route and another for the Montreal-Fort Lauderdale route, as shown in **Table 4**. The first column shows the model variables that were estimated. The other columns include the estimation values for the model parameters, followed by standard errors and p-values. Most of the p-values are low, indicating that the variables are statistically significant. Parameters with high p-values (aircraft A32N, E190 and SSJ1 on the route to Ft Lauderdale) are identified in italics

The negative price parameter values indicate that as ticket prices increase, passengers tend to shy away from that option, as expected. The parameters show weak interaction between prices and the fear of flying (price-fear), indicating that if FoF is strong, the effect of price changes is not consequential. However, the parameter is slightly positive, which implies that FoF passengers will buy more expensive tickets if they think that they are getting a safer aircraft or airline.

To compare aircraft preferences, we used the B777 as the benchmark. We observe that all aircraft choice parameter values are positive, indicating a preference for aircraft other than the B777. However, if we consider the interaction between aircraft choice and FoF, all parameter values are negative, indicating that passengers will increasingly select the B777 over all other aircraft if they fear flying. Therefore, passengers who do not fear flying would not choose the B777, perhaps because of the inconvenience of flying in a large plane with long boarding process. It seems that, as fear creeps in, the convenience of smaller aircraft becomes less appealing. However, only by analyzing the full spectrum of FoF can passengers' preferences be fully understood.

Destination	Mexico			Fort Lauderdale		
Parameter	*Estimate*	*Sd. Error*	*P value*	*Estimate*	*Sd. Error*	*P value*
Price	-0.550	0.038	< 0.001	-0.431	0.040	< 0.001
Price-fear	0.039	0.010	< 0.001	0.037	0.010	< 0.001
B73N	0.982	0.476	0.039	0.790	0.456	0.083
B73N-fear	-0.402	0.116	0.001	-0.385	0.131	0.003
B73M	1.310	0.493	0.008	0.968	0.511	0.058
B73M-fear	-0.540	0.143	< 0.001	-0.584	0.171	0.001
A320	1.926	0.394	< 0.001	0.900	0.399	0.024
A320-fear	-0.522	0.095	< 0.001	-0.299	0.100	0.003
A32N	2.114	0.396	< 0.001	*0.620*	*0.444*	*0.162*
A32N-fear	-0.607	0.100	< 0.001	-0.306	0.104	0.003
A220	1.087	0.461	0.018	0.935	0.447	0.037
A220-fear	-0.423	0.120	0.000	-0.427	0.127	0.001
E190	1.306	0.534	0.014	*0.192*	*0.447*	*0.667*
E190-fear	-0.524	0.136	< 0.001	-0.185	0.111	0.096
E192	1.417	0.477	0.003	0.828	0.467	0.077
E192-fear	-0.558	0.126	0.000	-0.467	0.152	0.002
SSJ1	0.925	0.525	0.078	*0.745*	*0.511*	*0.144*
SSJ1-fear	-0.488	0.131	< 0.001	-0.413	0.158	0.009

Table 4: Summary of Model Parameter Estimation

In the next step, we analyze the parameters described above and check the effect of FoF on these preferences. We will address the likelihood of selecting one aircraft among the set of nine models available. The results are presented by comparing a few airplane models at a time, analyzing all the options together would cloud the charts and confuse the analysis, making it difficult to extract meaning from the results.

The first comparison is between the members of the Boeing family (i.e., North American aircrafts): B73N, B73M and B777. As seen in the table, **Figure 3** shows that for passengers with a low FoF, the B777 is the least desired aircraft on both routes: Fort Lauderdale and Mexico City. This is more pronounced in the Mexico City route, for which the B777 is preferred only 4.6% of the time (yellow line in left chart), while it is the preferred aircraft in the Ft Lauderdale route 7.9% of the time. This is surprising because B777 is usually scheduled for long flights, and Mexico City is 2,300 miles from Montreal, while Fort Lauderdale is only 1,400 miles away. However, as FoF increases, passenger preferences change, and the B777 becomes the preferred alternative as can be observed in both cases where the B777 curve is convex and it monotonically increases. For the maximum FoF, this is the most preferable aircraft 51% of the time in the Mexico City route and 42% of the time in the Fort Lauderdale route.

Interestingly, an increased likelihood of choosing the B777 in a quasi-exponential manner was found for FoF travelers in both routes. However, this effect is more pronounced in the Mexican route. For example, in this model, considering the case where FoF is at its highest level, the B777 is 43.0% more likely to be selected compared to the B73N and 46.9% more likely to be chosen compared to the B73M. For the Fort-Lauderdale model, the relative increase in the likelihood of choosing the B777 over the B73N was 35.8%, and 40.2% when compared to the B73M. This is an indication that passengers for this destination are less prone to change aircraft based on the level of FoF.

This is further confirmed by the fact that, for passengers with no FoF, the most preferable aircraft in the Mexican case is the B73M. This is true up to a FoF level of 2.5, whereas beyond that level, this same aircraft becomes the least preferable. In contrast, when Fort Lauderdale is the destination, the B73M is the least preferable for all FoF levels, with the exception of the no FoF case, where it has the same likelihood to be chosen as the B73N, i.e., 11.7%. However, as FoF increases, the preference for the B73M drops to 4.3% in the route to Mexico City and to 1.9% in the route to Fort Lauderdale. The change in passenger attitude is greater when the destination is farther and more foreign to Canadian passengers. This could indicate that the notoriety gained by the B73M with the two major accidents has affected how passengers perceive aircraft safety. However, consumers tend to trust the Boeing company after all, as the shift to the B777 model occurs in a similar manner independent of the destination.

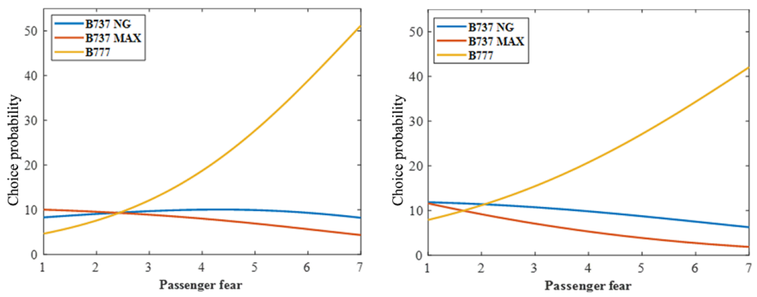

Figure 3: Likelihood of choosing Boeing aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

In **Figure 4**, the charts compare the preferences for the aircraft made by the Airbus: A320, A320 NEO and A220. Note that the scale in these charts is different from that in Figure 4, with a maximum likelihood of 25%. These two charts reveal an interesting client behavior change depending on the destination of the flight. For instance, when the destination is Fort Lauderdale, the curves for the two variants of the A320 are similar, being only offset by 4% in favor of the classic variant. In contrast, the A220 has an almost constantly decreasing choice probability as the FoF increases. When there is no FoF, this airplane has a probability of 13.1%, being preferred by passengers over the A32N up to a FoF level of 2.8. This is surprising since this a new clean-sheet aircraft that has yet to build a reputation of safety among passengers.

When the destination is the airport of Mexico City, the A220 has an almost constant likelihood of being chosen of around 9.5%, independent of the FoF level. On the other hand, the A32N presents a sharp and constant drop as the FoF increases. At one extreme, with minimal FoF, it is the preferable option among all Airbus options, but when the FoF is at a maximum, it is the least preferable option. The A320 follows closely, but it is preferable by an almost constant offset of 3.8% for passengers with mid to high levels of FoF. The passengers to the Mexican destination with low FoF, in contrast, would rather experiment with the modern features of the A32N, and when it comes to an American destination, they tended to prefer the former Canadian aircraft.

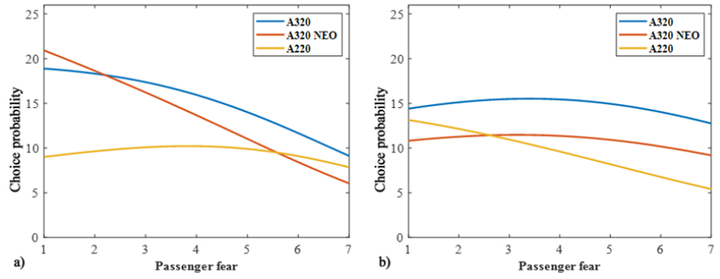

Figure 4: Likelihood of choosing airbus aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

The charts in **Figure 5** compare the other aircraft in the study, two manufactured by Embraer and one by Sukhoi. The scale changes again to a maximum of 16%. Boeing and Airbus are the best-known names in civil aeronautics, constituting a de facto duopoly. As expected, the aircraft in Figure 6 are preferred less frequently, perhaps because of lack of brand recognition. In fact, as FoF increases, the preference for these aircraft drops even further, with the surprising exception of the E190 in the Ft Lauderdale route, discussed below.

In the route to Mexico City, Embraer's airplanes are preferred regardless of FoF over the Sukhoi alternative. All three curves are concave, monotonically decreasing with travelers' FoF. Almost 30% of the passengers with low FoF would prefer one of the more modern aircraft (E190, E190-E2 or SSJ1), but as FoF increases, their combined preference drops to less than 20%. Once again, the more familiar B777 takes the preference away from the smaller aircraft.

A different response is observed when the destination is Fort Lauderdale. When FoF is low, the newer models (E190-E2 and SSJ1) are preferred over the E190, with SSJ1 being slightly preferred over the E190-E2. However, for travelers with high FoF, the E190 holds a significant advantage over the lesser known aircraft, perhaps because the E190 has a significant presence in the United States, with 60 units flying with the JetBlue livery. It seems that its familiarity provides some reassurance to passengers with high FoF.

The charts in **Figure 6** compare the better-known aircraft with the B73M, and it appears that the two disasters with the B73M had an impact on passenger preference, regardless of destination. Except for passengers with very low FoF, the B73M

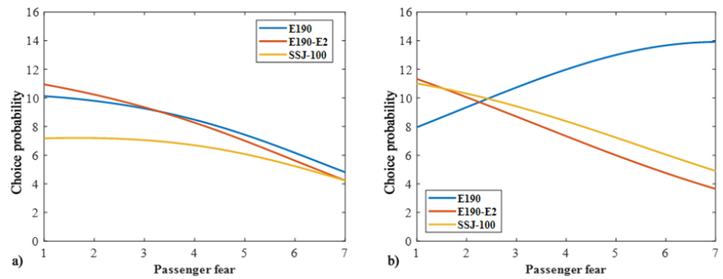

Figure 5: Likelihood of choosing Embraer or Sukhoi aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

is always the last choice among the more established aircraft. In comparison, the A320 is the top choice for travelers with low FoF, and B777 is the top choice for travelers with high FoF. In the Fort Lauderdale route, the range of preferences among the five choices is relatively small, from 7.9% to 14.4% among passengers with low FoF. However, in both routes, the B777 stands out, being preferred by approximately 50% of passengers with high FoF.

The privileged recognition enjoyed by the A320 makes it the top or second preference of passengers with all levels of FoF for both routes (except for the highest FoF in the Fort Lauderdale route), likely because this plane is well established around the world and has a good reputation. Note that in the case of the Mexican destination, the preference level for the B73M is very similar to that of the Embraer E190, whereas the B73N has a slightly higher preference than these two, especially when FoF is high.

From a technical viewpoint, either the B73M, the B73N or the A320 would be ideal for these international routes—unlike the aircraft designed for regional routes, such as Embraer's. Likewise, these are not intercontinental routes, such as those that the B777 was designed to serve. It appears that FoF increases the perception of distance, making it seem that only the largest airplanes would be suitable for these routes, which is not true.

The comparison between the B73M and other modern nonregional equivalents—the A320 NEO and the A220—helps to understand the impact that the two disasters have had on the American aircraft's reputation. **Figure 7** shows that, on the route to Mexico City, the preference for the A320 NEO is clear, except when FoF is greater than 5.7, at which point the preference switches to the A220. The opposite behavior is observed in the Fort Lauderdale route, for which the A320 NEO is still preferred, except when FoF is low. In both routes, the B73M holds the lowest preference among the three aircraft for almost every FoF level.

The preference for the B73M is probably lower due to the disasters that happened involving aircraft of that brand. Unfortunately, no similar study has been performed prior to the accident to test this hypothesis. The preference for this aircraft type is similar to that for the new A220 for passengers with low FoF. As FoF increases, this aircraft alternative becomes the least preferred, with a significant, but not huge, difference. However, the preference for the A220 in this study may be affected by our sample, which was selected entirely from the province of Quebec, which probably feels great pride in the A220 because its development cycle was completed in the region when the aircraft was designed by Bombardier as the C-series. It is possible that the preference for A220 would be lower otherwise.

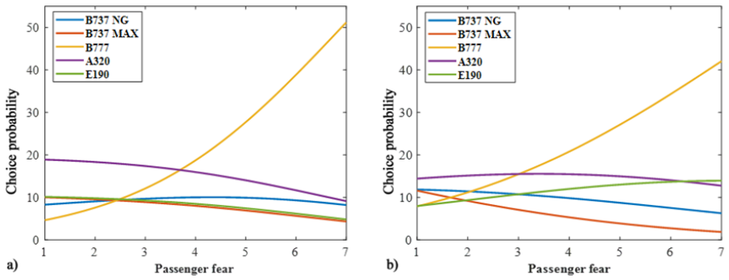

Figure 6: Likelihood of choosing established aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

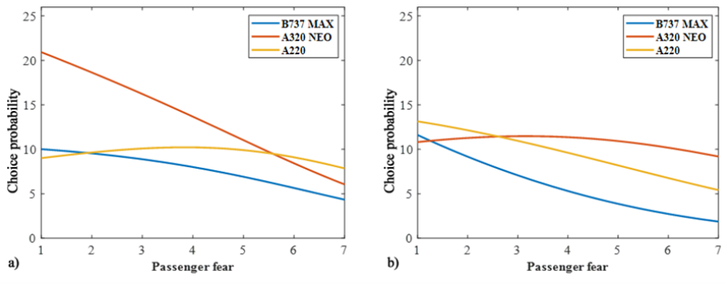

Figure 7: Likelihood of choosing newer Boeing or Airbus aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

Another possible external influence on the results is that Russian and Brazilian aircraft have not built a sufficient reputation in the West largely because of their country of origin. Furthermore, they are less known because the Airbus/Boeing duopoly has powerful marketing machines that are much stronger than those of Embraer or Sukhoi. Therefore, their models should be less preferred than the models by Airbus or Boeing. With that preamble, **Figure 8** shows the comparison between the B73M and the other modern jets.

In both routes, we notice that the B73M shares the same preference space with the aircraft from nontraditional manufacturers, in all FoF levels, almost never leading the pack. This is disturbing for the B73M, considering that it is being compared with two aircraft that currently have no presence in North America and are generally obscure to the North American public.

An important consideration is that the analysis of the results implies that the two disasters affected passengers' desire to fly the B73M but not to the extent that they would refuse to travel on that plane. However, the results indicate that the willingness to travel on this modern aircraft is comparable to those from nontraditional manufacturers. Nevertheless, the potential reputation loss of the model is mitigated by the outstanding reputation of Boeing Corporation, which is confirmed by the increasing preference for the better-known models such as the B777. Regarding the B73N, it seems that it suffered some residual degradation of its image, being preferred more frequently than the B73M but less often than its European competitors.

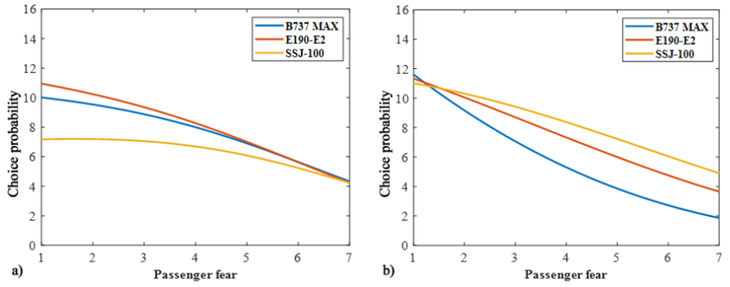

Figure 8: Likelihood of choosing B737M compared to lesser known aircraft. Destinations are Mexico City (left) and Fort Lauderdale (right)

5 CONCLUSIONS

Fear of flying is an important variable when evaluating air transport preference, and it is important to consider the impact of FoF on the performance of airline companies. Recently, the media provided significant coverage of the B73M aircraft disasters. The media coverage had a substantial impact on the aircraft's reputation and the airlines that employ that aircraft model saw considerable revenue losses due to the grounding of the aircraft.

This study modeled aircraft preferences and their interaction with FoF. To that end, potential passengers were asked to compare several sets of fictitious unlabeled tickets that were generated according to an orthogonal factorial fractional model. Each set had nine tickets. For these tickets, nine types of aircraft were proposed: three from Boeing, three from Airbus, two from Embraer and one from Sukhoi. The diversity of models and manufacturers allowed passengers' preference for the B73M to be compared to that for other models, varying from well-established aircraft (Boeing 777 or Airbus 320) to newcomers (Embraer E190-E2 or Sukhoi SuperJet 100).

The analysis generated parameters within the expected range with a high level of statistical significance. Several comparative scenarios were considered. It was noted that not all Boeing airplanes saw lost consumer preference after the MAX incidents, which were widely covered by the media. In contrast, the resulting models showed that in the presence of significant FoF, passengers turn to the B777 model, according to a convex

curve monotonically increasing with FoF. On the Airbus side, the classic A320 is the favorite model regardless of the FoF level. Among the models from this maker, the preference for the newer offerings, the A220 and A32N, tended to decrease as the FoF level increased. For these companies, it seems that an important factor affecting passengers' preferences is how well established the model is.

It appears that passenger confidence develops with the time that the aircraft has been in the market and established its reliability. When analyzing the aircraft of brands other than those from the European and American behemoths, passengers are less interested. It is difficult to establish exactly why—more studies in this sense are necessary. However, it is possible to hypothesize from the results and an analysis of the literature that this is because these are models that, although modern, come from less developed regions that have not established a reputation for building commercial aircraft. It also shows that marketing may have a very strong impact on passengers' perception of a product's quality because, considering their records, it cannot be said that the aircraft from nontraditional manufacturers are less safe. The only aircraft in this group that was significantly preferred in any of the comparisons was the E190 in the Fort Lauderdale route. This is probably because this model was able to establish itself in the domestic American market, notably with the JetBlue livery. Nonetheless, that level of preference drops in the route to Mexico City, which confirms the lower confidence of consumers in airplanes outside the Boeing-Airbus duopoly in most conditions.

Compared to the newer airplane models in this study, a preference for models other than the B73M is noticed. It seems that the preference for the B73M was affected by the two recent accidents widely covered by the media but that this loss of trust was not so intense that passengers would refuse to travel on that aircraft. This plane receives the same treatment from the public as the planes from nontraditional manufacturers. In the event of recertification (grounding restrictions lifted), with a subsequent reintegration of this aircraft type into the fleet of the main Canadian airlines, the B73M would immediately be considered in the air ticket offerings in a similar way as would the Sukhoi and the newer Embraer aircraft, which are modern but looked at by the North American public with some suspicion. One can expect that Boeing will have to invest in rebuilding an image of quality for the B73M brand once the safety concerns are resolved, exploiting its long history of reputable and safe products. However, the data and analysis suggest that passengers will need time before their confidence is re-established. An important note is that this whole study was carried out prior to the Covid-19 pandemic onset. Therefore, the results are free from any distortions caused by the general fear or negative perception of air travel due to the coronavirus spread. Further studies to determine the marketing strategies to restore the preference for the B73M in a pandemic scenario are necessary.

REFERENCES

Akamavi, R. K., Mohamed, E., Pellmann, K., & Xu, Y. (2015). Key determinants of passenger loyalty in the low-cost airline business. Tourism Management, 46, 528–545.

Alderighi, M., Cento, A., Nijkamp, P., & Rietveld, P. (2005). Network competition—the coexistence of hub-and-spoke and point-to-point systems. Journal of Air Transport Management, 11(5), 328–334.

Alderighi, M., Cento, A., Nijkamp, P., & Rietveld, P. (2007). Assessment of new hub-and-spoke and point-to-point airline network configurations. Transport Reviews, 27(5), 529–549.

American Psychiatric Association. (2013). Diagnostic and Statistical Manual of Mental Disorders. Philadelphia: American Psychiatric Association.

Baer, H. A. (2019). Airplanes, the Environment, and the Human Condition. London: Routledge.

Barnett, A. (2020). Aviation safety: a whole new World? Transportation Science, 54(1), 84–96.

Batouei, A., Iranmanesh, M., Nikbin, D., & Hyun, S. S. (2019). Flight anxiety: investigating the role of airline service quality and flight crew's competence. Asia Pacific Journal of Tourism Research, 24(7), 710–724.

Bergstra, J. A., & Burgess, M. (2019). A promise theoretic account of the boeing 737 Max MCAS algorithm affair. arXiv preprint arXiv:2001.01543.

Bewlay, B., Nag, S., Suzuki, A., & Weimer, M. (2016). TiAl alloys in commercial aircraft engines. Materials at High Temperatures, 33(4-5), 549–559.

Black, A., Crossley, W., & van Seeters, P. (2012). Investigations of perspectives for re-engining commercial single-aisle transport aircraft. Paper presented at the 12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and 14th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, Indianapolis, Indiana.

Boyd, D., & Hart, J. (2016). Potential utility of a cost-effective virtual reality system for treatment of fear of flying. Aerospace Medicine and Human Performance, 87(9), 830–832.

Braithwaite, G. R. (2017). Attitude or Latitude? Australian Aviation Safety. London: Routledge.

Bravo, A., & Vieira, D. R. (2019). A systematic review of the civilian airline industry: towards a general model of customer loyalty. International Journal of Business and Data Analytics, 1(2), 156–183.

Budd, L., & Budd, T. (2013). Environmental technology and the future of flight. In L. C. S. Budd, S. Griggs, & D. Howarth (Eds.), Sustainable Aviation Futures (pp. 87–107). Bingley, UK: Emerald Group Publishing Limited.

Buyck, C. (2018). Airbus Selects A220 as New C Series Brand. Aviation International News.

Cameron, D., & Wall, R. (2019). Airbus Poised to Overtake Boeing as Biggest Plane Maker. The Wall Street Journal.

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: a meta-analysis of randomized controlled trials. Journal of Anxiety Disorders, 61, 27–36. doi:10.1016/j.janxdis.2018.08.003

Coates, K. S., Healy, R., & Morrison, W. R. (2002). Tracking the snowbirds: seasonal migration from Canada to the USA and Mexico. The American Review of Canadian Studies, 32(3), 433–450.

Corallo, A., De Maggio, M., & Storelli, D. (2010). SuperJet international case study: a business network start-up in the aeronautics industry. In G. Passiante (Ed.), Evolving Towards the Internetworked Enterprise (pp. 133–145). Boston, MA: Springer.

Cruz, B. S., & Dias, M. D. O. (2020). Crashed boeing 737-Max: fatalities or malpractice? GSJ, 8(1), 2615–2624.

Cutler, R. M. (2019). Ten Reasons to Defer Boeing 737 Max Recertification. Technical Report.

Czerniak, E., Caspi, A., Litvin, M., Amiaz, R., Bahat, Y., Baransi, H., . . . Plotnik, M. (2016). A novel treatment of fear of flying using a large virtual reality system. Aerospace Medicine and Human Performance, 87(4), 411–416.

Desrosiers-Lauzon, G. (2009). Canadian snowbirds as migrants. Canadian Issues, 1, 27–32.

Dimitrios, D. J., John, M. C., & Maria, S. F. (2017). Quantification of the air transport industry socio-economic impact on regions heavily depended on tourism. Transportation Research Procedia, 25, 5242–5254.

Ekeberg, Ø., Fauske, B., & Berg-Hansen, B. (2014). Norwegian airline passengers are not more afraid of flying after the terror act of September 11. The flight anxiety, however, is significantly attributed to acts of terrorism. Scandinavian Journal of Psychology, 55(5), 464–468.

Fleischer, A., Tchetchik, A., & Toledo, T. (2012). The impact of fear of flying on travelers' flight choice: choice model with latent variables. Journal of Travel Research, 51(5), 653–663.

Forbes. (2019). After 900% Increase in 2018, Airline Fatalities Rising Again. Retrieved from https://www.forbes.com/sites/michaelgoldstein/2019/05/07/after-900-increase-in-2019-airline-fatalities-rising-again/#1ef47c297190

Foreman, E. I., Bor, R., & Van Gerwen, L. (2016). Flight or fright? Psychological approaches to the treatment of fear of flying. In T. Hubbard & R. Bor (Eds.), Aviation Mental Health (pp. 69–83). London: Ashgate.

Forgas, S., Moliner, M. A., Sánchez, J., & Palau, R. (2010). Antecedents of airline passenger loyalty: low-cost versus traditional airlines. Journal of Air Transport Management, 16(4), 229–233.

Gerwen, L., & Koopmans, T. (2018). Self-help treatment for fear of flying. Aeronautics and Aerospace Open Access Journal, 2(3), 184–189.

Gilbert, D., & Wong, R. K. C. (2002). Passenger expectations and airline services: a Hong Kong based study. Tourism Management, 24(5), 519–532.

Gomes, S. B. V. (2012). A Indústria Aeronáutica no Brasil: Evolução Recente e Perspectivas. Rio de Janeiro: Banco Nacional de Desenvolvimento Econômico e Social.

Gomes, S. B. V., Barcellos, J. A., & Tucci, N. (2018). Embraer e boeing vis-à-vis Airbus e Bombardier: quais as implicações para o Brasil? BNDES Setorial, 47, 63–121.

Han, H., Yu, J., Chua, B. L., Lee, S., & Kim, W. (2019). Impact of core-product and service-encounter quality, attitude, image, trust and love on repurchase. International Journal of Contemporary Hospitality Management, 31(4), 1588–1608.

Hensher, D. A., & Greene, W. H. (2003). The mixed logit model: the state of practice. Transportation, 30(2), 133-176.

Johnston, P., & Harris, R. (2019). The boeing 737 MAX saga: lessons for software organizations. Software Quality Professional, 21(3), 4–12.

Klein, R. A. (2000). Virtual reality exposure therapy in the treatment of fear of flying. Journal of Contemporary Psychotherapy, 30(2), 195–207.

Machado, M. A., & Hatakeyama, K. (2018). From technology transfer to disruptive innovation: the case of embraer. Paper presented at the 2018 Portland International Conference on Management of Engineering and Technology (PICMET), Honolulu, HI, USA.

Mühlberger, A., Alpers, G. W., & Pauli, P. (2005). Fear of flying in the wake of September 11: no evidence for an increase in a German sample. Anxiety, Stress, and Coping, 18(4), 343–349.

Mühlberger, A., Herrmann, M. J., Wiedemann, G., Ellgring, H., & Pauli, P. (2001). Repeated exposure of flight phobics to flights in virtual reality. Behaviour Research and Therapy, 39(9), 1033–1050.

Mühlberger, A., Weik, A., Pauli, P., & Wiedemann, G. (2006). One-session virtual reality exposure treatment for fear of flying: 1-year follow-up and graduation flight accompaniment effects. Psychotherapy Research, 16(1), 26–40.

National Safety Council (NSC). (2020). Injury Facts: Preventable Deaths. Retrieved from https://injuryfacts.nsc.org/all-injuries/preventable-death-overview/odds-of-dying/data-details/

NYT. (2019). Ethiopian Airlines Plane is the 2nd Boeing Max 8 to Crash in Months. The New York Times.

Pappachan, J., & Koshy, M. P. (2018). Effects of economic growth on the development of civil aviation market-a study based on development status of selected economies. Vilakshan: The XIMB Journal of Management, 15(1), 67–88.

Petrescu, R. V., Aversa, R., Akash, B., Corchado, J., Apicella, A., & Petrescu, F. I. (2017). Home at airbus. Journal of Aircraft and Spacecraft Technology, 1(2), 97–118.

Price, M., Anderson, P., & Rothbaum, B. O. (2008). Virtual reality as treatment for fear of flying: a review of recent research. International Journal of Behavioral Consultation and Therapy, 4(4), 340–347.

Rothbaum, B. O., Hodges, L., Smith, S., Lee, J. H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. Journal of Consulting and Clinical Psychology, 68(6), 1020–1026. doi:10.1037//0022-006x.68.6.1020

Sengupta, S., Donekal, A. K., & Mathur, A. R. (2016). Automation in modern airplanes-a safety and human factors based study. INCOSE International Symposium, 26(s1), 386–394.

Shahrabani, S., & Regev, S. T. (2019). Willingness to pay for airline security. International Journal of Culture, Tourism and Hospitality Research, 13(2), 153–166. doi:10.1108/IJCTHR-06-2018-0080

Sherman, B. (2003). Evolution of the boeing production system (presentation). Paper presented at the IIE Annual Conference: Proceedings.

Shiban, Y., Diemer, J., Muller, J., Brutting-Schick, J., Pauli, P., & Muhlberger, A. (2017). Diaphragmatic breathing during virtual reality exposure therapy for aviophobia: functional coping strategy or avoidance behavior? A pilot study. BMC Psychiatry, 17(1), 29. doi:10.1186/s12888-016-1181-2

Stewart, S. (2014). Flying the Big Jets. Ramsbury: Crowood.

Teal, M. (2014). New 737 MAX: Improved Fuel Efficiency and Performance. Boeing AERO Magazine.

Teketay, D. (2017). Assessing the Factors that Contribute for the Performance of Cfm56 Engine in the Case of Ethiopian Airlines. Addis Ababa, Ethiopia: Addis Ababa University.

Temesgen, D. (2019). Crisis Communication Strategies of Ethiopian Airlines Group: A Case Study of Flight 302 Accident. Addis Ababa, Ethiopia: Addis Ababa University.

The World Bank. (2019). Air Transport, Passengers Carried. Retrieved from https://data.worldbank.org/indicator/IS.AIR.PSGR

Tyrinopoulos, Y., & Antoniou, C. (2020). Review of factors affecting transportation systems adoption and satisfaction. In C. Antoniou, D. Efthymiou, & E. Chaniotakis (Eds.), Demand for Emerging Transportation Systems (pp. 11–36). Amsterdam and Kidlington: Elsevier.

van Gerwen, L. (2017). Psychological Perspectives on Fear of Flying. London: Routledge.

Vieira, D. R., & Bravo, A. (2016a). Feasibility of green composite aircraft wing projects for unmanned aircraft vehicles. International Journal of Sustainable Aviation, 2(3), 248–270.

Vieira, D. R., & Bravo, A. (2016b). Life cycle carbon emissions assessment using an eco-demonstrator aircraft: the case of an ecological wing design. Journal of Cleaner Production, 124, 246–257.

Wendel, W. B. (2019). Technological solutions to human error and how they can kill you: understanding the boeing 737-Max products liability litigation. Cornell Legal Studies Research Paper No. 19-47. doi:10.2139/ssrn.3430664

Zhang, B. L., & Xiang, H. (2013). Application of airplane accidents statistics to pilot errors causality analysis. Zhongguo Anquan Kexue Xuebao, 23(3), 114–118

ABOUT AUTHORS

Alencar Bravo is a doctor engineer from the University of Quebec at Trois-Rivières and he is a professor of project management at the same university. He also holds two professionals' master's in mechanical engineering from the National Institute of Applied Sciences in Lyon (France) and the Polytechnic University of Catalonia (Spain). He has significant experience in the field of industrial research and development projects of high technical complexity, especially in the automotive and aeronautical fields. Other areas of research interest include eco-design tools, techniques and methods, life cycle management and total cost of ownership, uncertainty and risk management, customer behavior, and management and support systems in projects.

Darli Rodrigues Vieira, Ph.D., is a full professor of Project Management at the University of Quebec in Trois-Rivières (UQTR). He is currently the Head of the Management Department and Director of the Master's program in Project Management at this university. His current research focuses on project management, defense projects, product lifecycle management, new product development, supply chain management, strategy and management of operations, and management of MRO (Maintenance, Repair & Overhaul). He has over 25 years of professional experience in a variety of roles and industries. Also, he was the holder of the Research Chair in Management of Aeronautical Projects (2013 – 2019).

Professor Geraldo Ferrer is the Chair of Supply Chain Management at the Naval Postgraduate School. He is an expert in the areas of global operations, supply chain management, sustainable technologies, product stewardship, reverse logistics and remanufacturing. He has studied the reverse logistics required in recycling and remanufacturing operations, and inventory problems affecting products made in small batches for frequent deliveries. He has presented his research in national and international conferences in four continents, and in invited seminars in various academic institutions. Dr. Ferrer has consulted for companies in the United States and abroad on process improvement, waste reduction and reverse logistics issue. He has published more than 20 articles on these topics in several prestigious journals. He received his Ph.D. from INSEAD, his MBA from Dartmouth College, a mechanical engineering degree from the Military Institute of Engineering in Rio de Janeiro and a BA from the Federal University of Rio de Janeiro. Prof. Geraldo Ferrer has been invited to teach in executive education program in several universities in the USA and abroad. He has been with the Naval Postgraduate School since 2004.