Modelling Consumer Choice Behaviour in Space Tourism

Abstract

This paper presents the results of stated-preference, discrete-choice experiments designed to examine potential consumer reactions to various options emerging in the embryonic space tourism industry. The research investigated choice behaviour between four types of space tourism: high-altitude jet fighter flights, atmospheric zero-gravity flights, short-duration sub-orbital flights, and longer duration orbital trips into space. Each type of space tourism was represented in terms of an array of major features that potentially may have a major impact on the perceptions, attitudes, and choice behaviour of likely customers in this market. The choice experiments were embedded in an information-rich, online survey. Choice data from the experiments were analysed with the mixed-logit model, which is a random coefficient model that allows for a continuous distribution of the preferences (effects) for each feature. The results identify a number of features for each type of flight option as well as a number of customer characteristics that appear to impact the choice of space tourism type.

Keywords: space tourism, discrete choice modelling, choice experiment, consumer behaviour.

1. Introduction and Background

Since the publication of Schumpeter's *Theory of Economic Development* (Schumpeter, 1961), it is well-recognized that the birth of new industries creates a dilemma for understanding and predicting consumer choice behaviour. New industries typically present customers with conceptually or practically radical products that do not benefit either from the advantage of being able to reflect on past patterns of demand and choice, or from a history of competitive offerings, variations in product features, and market share performances.

Thus, there is little basis for extrapolation and, at best, only poor market analogues (Gregan-Paxton, Hibbard, Brunel and Azar, 2002) exist to provide entrepreneurs with some basis for anticipating or gaining insights into likely customer responses to really new products. Despite this challenge, the need to understand how consumers are likely to react to radically new product and service offerings is particularly acute in these circumstances. Unlike well-established markets, where more 'incremental' products are the norm, the risks, uncertainties, investment, and potential commercial rewards at stake are often considerably greater (Song, 1998).

The birth of 'space tourism' is a case in point. If the likes of Richard Branson are to be believed, the next few years could herald in a space tourism industry that is nothing short of an economic 'behemoth' if it succeeds to the same extent as the civil aviation industry during the 20th century. From the first powered flight in 1903 through the early 'barnstorming' years of flight, advances in aircraft technology stimulated by two world wars, the development of jet aircraft engines, and most notably the Boeing 747, aviation advanced rapidly during the first several decades of technological and then commercial development. According to Michael Belfiore (2007a):

> *"Private companies took air travel out of the exclusive domain of militaries and governments and gave it first to the very rich; then low cost carriers such as Ryanair started turning around aircraft faster, increasing the frequency of flights and thus making them affordable for many more people. Space travel is taking the first step in this process."*[1]

However, forecasts of demand for the products and services of this industry require particular caution as the prevailing view in the 1960s and 1970s, during the heydays of the

[1] See also Belfiore (2007b) for a useful reference detailing the pioneers involved in creating a commercial space tourism industry.

space race, was that by the late 20th Century the general public would already be travelling into space *en masse*. The benefit of hindsight tells us that this was an overly optimistic expectation based more on hope than on realistic assessments or appreciations of the costs, technical realities, risks, and/or commercial imperatives space tourism requires.

Nonetheless, hopes and expectations have been renewed over the past several years in light of a number of developments (Crouch, Laing and Smith, 2004) including:

- flights of several, fare-paying tourists (Malik, 2005; Carey, 2005) to the International Space Station via the Russian Soyuz spacecraft, with the assistance of *Space Adventures*, a commercial space tourism 'go-between'.
- the first successful flights of SpaceShipOne (a sub-orbital venture) to win the Ansari XPrize (David, 2004), followed by the announcement that the company that designed and built SpaceShipOne (i.e., Scaled Composites) had entered into an agreement with a new venture created by Sir Richard Branson (known as Virgin Galactic) to build a fleet of sub-orbital spacecraft for space tourism based on the SpaceShipOne prototype (David, 2005b).
- a change in the attitudes of NASA and US policy makers and regulators who now seem to be willing to facilitate and encourage development of the industry and ensure that the lead of the United States is maintained (Werner, 2004; David, 2005a). The US Federal Aviation Administration has adopted the lead regulator role at this stage and has sought to facilitate rather than hinder the development of sub-orbital space tourism enterprise.
- a flurry of other developmental activities involving design, testing, and facilitating of sub-orbital and orbital initiatives and ventures including the participation of, and investment by several wealthy individuals (see Malik, 2004; David, 2005c, 2005d, 2005e for examples).

- willingness of market mavens to buy into the initial product concepts. Sir Richard Branson's Virgin Galactic has sold out its Founders Group with 100 individuals preparing to pay $200,000 for flight of just under two hours. The company, Space Adventures, which to date has played a role in assisting the Russian Space Agency to find space tourism customers for its Soyuz flights to the International Space Station, has over 200 people prepared to pay $100,000 for a 90-minute sub-orbital flight.

Such developments suggest we are seeing the birth of a nascent commercial space tourism industry, although the way ahead appears very uncertain, with a wide range of economic, technological, political, legal, environmental, financial and commercial issues eventually shaping the rate and direction the industry takes. Industry experts are keenly aware that among the most important of these uncertainties is the way in which consumers perceive and respond to the competitive options on offer. For example, many in the industry expect that prices will fall, allowing the industry to become more mainstream. According to Will Whitehorn, president of Virgin Galactic: "We hope ticket prices will come down by the end of the first decade of flight as all profits prior to this will be reinvested in the business." Yet when pressed on what future prices might be, his response was telling: "On an unproven business model, we cannot accurately give that figure currently" (Kolesnikov-Jessop, 2006). In such circumstances, valid, reliable and accurate estimates of market demand are essential to capture the interest, participation and cooperation of many disparate businesses, organisations and individuals, and particularly capital markets. Simberg (2000, p. 10) suggests that "the current technology level is the least of the problems confronting space tourism entrepreneurs … the most difficult problem remains not in design and implementation, but in raising needed investment funds." Although venture capitalists such as Boston Harbour have provided support for space tourism ventures "wooing venture capitalists and private equity firms has proven more difficult. Such investors are skittish [not only] because commercial human spaceflight is risky [but because] firms compete with traditional software, internet, biotechnology and medical-device start-ups where the risk is lower and returns are potentially higher" (Sydney Morning Herald, 2007). As O'Neil et al. (1998) note, "validation of the real market for general public space travel and tourism is going to be an essential step. A central issue will be: is it possible to get that validation with current vehicles?" (p. 8). In light of these challenges, the purpose of this paper is to take a modest step in the direction of assessing the demand for certain types of space tourism services. We did so by modifying and applying a promising approach to modelling and forecasting the likely consumer response. Our analysis allowed us to explore the effect of various configurations of specific features which may form potential future space tourism offerings.

2. Space Tourism and Consumer Choice

2.1 Current Evidence of the Demand for Space Tourism

Several studies of the potential public interest in space tourism have been conducted over the last decade, either by "independent" academic researchers, government or public organisations, or commercial enterprises wishing to verify their belief that space tourism is a viable investment. Crouch (2001) reviewed and compared the results of many of these studies, undertaken in Japan, the US, Canada, Germany and the UK. Overall there was some broad consistency in the findings indicating that about 40% to 80% of respondents in these studies had an interest or desire to travel into space depending on nationality, gender (females expressed interest that was 5 to 10 percentage points lower than males), and age (80% for those under age 20, declining to 45% for those over 60). Crouch also reported that about 10% to 20% of respondents stated that they would be prepared to spend a year's salary to travel into space.

Futron Corporation (2002), in a study for NASA, surveyed 450 affluent Americans. They concluded that suborbital space travel could reach 15,000 passengers annually by 2021, representing revenues in excess of US$700 million, and that orbital travel could reach 60 passengers per year amounting to revenues of US$300 million by 2021. Perhaps surprisingly, half the respondents indicated that they would be indifferent to travelling in a privately developed suborbital vehicle with a limited flight history, versus a government-developed spacecraft. Similar to other studies, Futron concluded that "[o]rbital travel is a fairly elastic market; there are significant jumps in demand when the price drops to US$5 million and again at US$1 million" as the price for orbital travel is expected to decline over time from the current level of US$20 million.

In a comparative study, Crouch and Laing (2004) assessed Australian public interest in space tourism using a survey approach similar to several studies summarised above. They found a level of interest in the prospects for public space travel in Australia broadly comparable to the results of similar studies in Japan, the US and Canada, the UK, and Germany. Their findings suggest that, conceptually at least, most respondents would like to travel into space if they could (58%), but cost, safety, and product design factors would significantly impact their responses. Demographic and behavioural characteristics of consumers also were strongly associated with their attitudes and interests. Younger and male respondents were significantly more interested in space tourism and, as might be expected, there was a strong positive association between current risk-taking behaviour in recreation and leisure activities and a desire to travel into space. Consistent with other survey results, the question, "How long would you like to stay in space?", resulted in a modal response of two to three days (37%). Although the majority of respondents indicated they would be prepared to pay between one to three month's salary for such an adventure, 12% indicated they would be willing to forego a year's salary or more.

2.2 The Challenge of Evaluating Demand and Choice Behaviour in the Context of New and Emerging Industries

Although the research results summarised above are interesting, they capture little more than unincentivised interest by individuals who may not know or understand the product they were asked to evaluate. What is more, space tourism operators and regulators have a critical operational and financial need to be able to obtain a reasonably accurate prediction of the true demand for space tourism instead of guessing based on individuals' interests or desires. As we earlier noted, it is very hard to predict demand for products and services in radically new industries because there is no past market demand, track record and/or history, and there are no effective existing analogues that can be used to estimate future demand. Moreover, market demand is not a single quantity waiting to be discovered or revealed. Rather, it is a function of the characteristics of products offered and the market environment co-created by regulators, consumers and participating firms. As noted by Aggarwal, Cha and Wilemon (1998) radically new products create circumstances where market structures can be put into flux, consumers are required to learn about the products and their demand for it, and consumers also can change their behaviour(s) due to new products and markets. More broadly, this implies that there are many possible market demands, and any one of which can turn out to be actualised. Thus, one should predict potential future demand for space tourism as a probability distribution that can be modelled as a function of many factors, some of which include:

- prices of various space tourism options,
- risks inherent in the options,
- competitive dynamics as the industry unfolds between different space tourism ventures and different forms of space tourism (i.e., zero-gravity flights, sub-orbital space tourism, orbital space tourism, etc.),

- wide array of features that define space tourism options that can be varied by the operators as ways to enhance demand (e.g., duration and level of training required, type of launch and return spacecraft used, national identity of the operator, launch location, duration of the flight, etc.),

Thus, estimating and forecasting the size of the space tourism market is challenging, and fraught with a number of empirical hurdles that cannot be resolved with surveys that ask simple one-at-a-time questions. Public expressions of attitudes or interests in space travel and tourism do not measure real future demand or choice. Indeed, much research experience suggests that marketing research surveys typically overestimate true demand, particularly in the short term. Specifically, potential space tourism consumers currently know very little about space tourism and/or the features of space tourism products and the experiences that may emerge in the years ahead. Such lack of consumer knowledge and information suggests further caution over the conduct and interpretation of market research studies is warranted.

The preceding discussion implies that investigations of the demand for space tourism must account for: 1) specifics of the characteristics of the products on offer and their relationship to the likelihood of taking up a space tourism adventure, such that the nature of demand is a combinatorial function of the characteristics of the product; 2) lack of information and experience of potential consumers that creates a nascent information environment surrounding the market; and 3) different types of alternatives in the market that could compete with a space tourism alternative. The next section will discuss how our methodology addresses these issues.

3. Research Method

3.1 Choice Modelling and Information Acceleration Methods

Our approach must address the combinatorial nature of the potential characteristics of space tourism demand in a way that is behaviourally sound. To wit, we use discrete choice experiments (DCEs) and associated discrete choice models (DCMs) to understand and quantify the choices that consumers are likely to make among space tourism options. This theory-driven method "has proved valuable in empirical applications. … In travel and tourism research, random utility models have received considerable academic and industry attention and become a well-established framework" (Baltas 2006, p. 25). DCEs and associated DCMs allow one to decompose the independent contributions of the many factors that comprise a space tourism experience. A DCE is a designed 'choice experiment' in which the features (variables) of interest are systematically varied using statistical design theory. Pioneered by Louviere and Woodworth (1983, see also Louviere, Hensher and Swait, 2000), DCEs are widely used to evaluate product preferences and willingness to purchase by designing choice scenarios that closely simulate the choices that consumers face in real markets. In a space tourism context such choices may be driven by many factors of potential interest.

However, despite the sophistication of DCMs, one must be very cautious about the way in which one designs and implements DCEs in environments where potential customers have little or any knowledge or experience about product features and options available in the market. As noted by Krieger et al. (2003), products where consumers have no understanding of the product in question require "informational bridges" between the buyer's current experiences and the functionality of the new product. Hence, we must create an environment where consumer demand is not confounded by the customer's uncertainty about what a product actually delivers. In the space tourism context this is particularly important as it is unlikely that many consumers understand much about the nature of the experience or the associated risks. They also are unlikely to understand that there are alternatives in the market like zero-gravity flights that give them much the same experience at considerably lower prices and with higher safety margins and more convenience (one does not have to go to a spaceport). To deal with the problem of limited knowledge and experience about space travel and tourism by consumers, we use information acceleration (IA) methods pioneered at MIT (Urban et al. 1996), and extended by the Future Choice Initiative (Devinney, Louviere and Coltman, 2004). IA involves construction of sets of future scenarios that allow consumers to better understand future choice situations that they may face. IA uses information and multi-media technology to “accelerate” consumer learning and experience, enabling one to develop and implement DCE surveys that include a wide array of information, features, risk/benefits and contexts that consumers need to understand and experience in order to make informed decisions about future services.

IA methods have been used to study innovative product concepts ranging from radical automobile designs to sophisticated internet based services (see, Urban et al. (1997) and Krieger et al. (2003) for some examples). Krieger et al. (2003) describe how DCMs “can be embellished to obtain relevant information about consumer evaluations of new goods and services prior to their actual use by prospective consumers” (p. 6). This information not only is for estimating demand, but it also can serve as critical input to redesign more effective products and services. Veryzer (1998) outlines various methods that firms can use to help design better products and services in discontinuous environments, and how they deal with potential customer resistance points like familiarity, uncertainty and risk avoidance. His research suggests that customer input may not be the impetus behind a product’s development, but timely input in the right manner can lead to better alignment of product specifications with latent customer needs. Our approach is in line with this. Not only does an IA approach allow one to study product specifications, but it also allows us to study the role of information (e.g., how people are likely to react when they know what the experience is all about) and the availability and price of current (e.g., zero-gravity flights) and future (e.g., orbital flights) product competitors.

3.2 Space Tourism Types and Features

Future space tourism services can take on several different forms. For example, Crouch (2001) identified and described five types: a) terrestrial or land-based forms of space tourism (simulations), b) high-altitude jet fighter flights, c) zero-gravity flights, d) sub-orbital flights and e) orbital space tourism (and inter-planetary space tourism, longer term). For the purpose of this current study, we did not study terrestrial forms of space tourism like museums, ground space facilities and visitor centres, launch viewing, astronomy facilities or locations, etc. Such interest and activity is an important breeding ground for potential space tourism consumers, and might therefore be of use in profiling certain potential market segments. But in terms of the choice behaviour trade offs between the various forms of space tourism flight options, terrestrial space tourism services are minimally relevant to those services involving some type of actual flight (e.g., b to e above).

Our primary research focus is on commercial prospects for sub-orbital space tourism. We chose this focus because prototyping and commercial developments seem to be progressing quickly and, hence, represent the most likely short-run growth opportunity for a large number of space tourists. Additionally, recent developments in commercial zero-gravity flight offerings serve as a potentially attractive alternative to prospective space tourists who presently cannot afford and/or are unwilling to risk sub-orbital flights. In contrast, although orbital space tourism flights will continue, it is unlikely to grow beyond current arrangements for one to two individual space tourists to the ISS per year in the near term.

Individuals interested in one of the four space tourism flight experiences face an array of distinctly different options, each possessing many features. The theory that underlies DCEs and DCMs postulates that consumers will evaluate these options in terms of the various feature variations each offers. That is, they will compare and contrast the features of each option *within* each of the four space tourism types as well as *between* each type. For example, an individual considering choosing a sub-orbital space flight will evaluate features of competing sub-orbital space flight options as well as features of other options ranging from high-altitude jet fighter flights to zero-gravity flights and orbital options.

The latter consideration dictates that we model choices among these four types of space tourism offerings. However, because the industry's current interest and short-term prospects lie in zero-gravity and sub-orbital flights, we focused most of our research attention on them. That said, we included jet fighter and orbital space flights, but these two options received less direct attention in our research as discussed below. To make our research tractable, we designed two DCEs, each of which offered three space tourism options. The first DCE focused on *zero-gravity flights* competing with an 'inferior' option (high-altitude jet fighter flights) and a 'superior' option (sub-orbital flights). The second DCE focused on *sub-orbital space flights* competing with zero-gravity and orbital space flights as inferior and superior options, respectively. Because of the large number of features per option there are an enormous number of possible choice options. Hence, we had to constrain the size of the DCE to a manageable number of designed choice options to ensure that the survey was feasible. We accomplished this by limiting the number of features that described the inferior and superior options in each DCE to four, while at the same time allowing the target option to have a wide array of features and feature levels.

Table 1 briefly lists the features used to describe each of the four space tourism types. Each feature was assigned 2, 4, or 8 levels to describe a range of possible values that the feature could take on now and in the future. For example, table 2 lists levels associated with each feature for the limited profile employed to model sub-orbital space flights (an expanded list is available from the authors). Features and levels that we used were derived from a comprehensive review of the space tourism literature associated with conferences, reports, media information and web sites, together with input and feedback from several industry experts representing different areas of knowledge and expertise. Other aspects of our research design are described below.

INSERT TABLES 1 AND 2 ABOUT HERE

3.3 Research Design

A large fractional factorial choice experiment was used to design DCE choice scenarios. Each choice scenario consisted of descriptions of the target, inferior and superior space tourism options. The total number of features of all four types of space tourism options is large; consequently, a complete factorial enumeration of all of the feature and levels produces vast number of possible combinations. Thus it is practically impossible to show all possible combinations to respondents, even if we block the survey into versions with different choice sets (combinations of feature levels). Such cases typically dictate the use of fractional factorial designs, which represent a purposeful sample from the complete factorial that allows the effects of interest to be estimated, while assuming that other effects are insignificant. In our case, we designed the DCE based on an orthogonal main effects plan (OMEP).

The final survey instrument is shown in Appendix 1 and has three main components:

1. An **information section** that outlines the various types of space tourism. The aim of this component is to offer respondents as much information as possible so that they can make informed decisions about the four space tourism options in the DCE. We developed a set of comprehensive, visually rich information to increase: a) the salience of specific experiences that people might expect to have, and b) their

understanding and comprehension of what such experiences involve. This section also included definitions of the features of each space tourism option, which was available to participants throughout the survey in the form of a glossary.

2. A **DCE component** containing 16 choice sets. The first eight choice sets focused in detail on zero-gravity flights and accounted for the impact of high-altitude jet fighter flights and sub-orbital space tourism flights. A further eight choice sets were presented focusing in detail on sub-orbital space tourism compared to zero-gravity flights and orbital space tourism flights. A glossary of descriptions of the features of the four types of space tourism options was made available in the survey, and is shown in table 1. Feature levels were defined numerically, verbally, and, in some cases, visually. For example, zero-gravity aircraft type was depicted using external and internal photographs of the aircraft, showing passengers floating freely in simulated zero gravity. The amount of space per passenger on the zero-gravity flights also was shown using photographs of different levels of passenger crowding. The four levels of launch craft/sub-orbital craft/return craft combinations used a combination of verbal descriptions and images illustrating the main features of each. Differences in various levels of parachute training that might be required also were described using photographs.
3. A number of **demographic and lifestyle** questions along with the Zuckerman (1994) Thrill and Adventure Seeking 10-item subscale (TAS). The TAS has been used extensively to gauge an individual's tendency to undertake risky activities like extreme sports (e.g., Zuckerman, 1983), gambling (e.g., Hong and Jang, 2005) and related leisure activities (e.g., Barnett, 2006); it also has been related to consumption behaviour and variety seeking in consumers (e.g., Hirschman and Holbrook, 1982; Menon and Kahn, 1995), and individual-level financial risk taking (Wong and Carducci, 1991). The intent of this section was to generate data suitable for segmentation and targeting. Items covered leisure and adventure activities pursued and equipment owned; any certifications, licenses or special training in leisure

activities; travel behaviour to adventure locations; any exceptional activities like military training, flight experience, or unusual wilderness activity; emergency services work; and a series of dichotomous questions that collectively measured attitude toward risk. Demographic questions included covariates like gender, age, income, education, and the value of assets including residential property, investment property, pension funds, and investment portfolios.

Each of the choice sets in part 2 of the survey represented a future situation in which participants were offered three competing options.[2] Each option was explained in terms of the key features described above and illustrated in Appendix 2. The value or level of each feature associated with each option in each scenario was determined by the fractional factorial experimental design used to construct the DCE.

Each participant responded to each scenario by answering three questions: 1) which of the three options they preferred most, 2) which one they preferred least and 3) whether realistically they actually would spend time and money on any of the options if they were available in the next 12-24 months, including the option of not undertaking any form of space tourism flight. This allowed us to develop a preference ordering for each participant and estimate the extent to which they actually would choose an alternative if it was available.

What distinguishes our study from prior survey-based research is that it we can examine how individuals make tradeoffs between different types of space tourism, and between the feature levels associated with each type. By utilising a rich multimedia IA approach we create a realistic environment for making decisions and for understanding what the options actually entail. Thus, our approach captures the features of the specific types of options chosen, and does not rely on the potentially ill-conceived and/or ambiguous ideas that

[2] The scenario provides an assessment of the role that the features play in influencing choice between, but not within, each of the four types. It would, however, be straightforward to design a similar but different choice experiment that examined choice among options within one of these types of space tourism options, such as sub-orbital space tourism.

survey respondents may have about what space tourism actually entails. That is, unless all respondents agree on the underlying facts and the details of space tourism products and services, answers to questions about choices that they may make in the future can be very unrealistic and misleading, resulting in inaccurate forecasts.

3.4 Data Collection

Data were collected from a sample drawn from an online consumer panel of more than 300,000 Australians who opt to participate in surveys. Participants have an account and receive payment for participating. Accumulated earnings can be redeemed for gift vouchers or transferred to bank accounts. The panel's profile is designed to match the general Australian population on many key demographic factors.

We pilot tested the survey to ensure that instructions, wording, explanations, and questions were clear and formatted properly and efficiently. Importantly, the pilot indicated that subjects had no difficulty completing the 16 scenarios described earlier. We also found that 16 scenarios had little impact on survey response rates. The final survey obtained 783 usable responses during the period in which it was available to panel members.

4. Results and Discussion

4.1 Profile of Survey Respondents

Our sample consists of predominantly high income and/or high net-worth individuals. The 90th percentile for individual weekly disposable income in Australia in 2003 was around AUD$850, which would be approximately AUD$1,130 before taxes, or AUD$59,000 annually. About 70% of our sample is above the 90th percentile in annual household income; hence, it was targeted towards individuals who have incomes or net worths that potentially would allow them to pay the prices of the services studied.

The composition of the sample is described in more detail in table 3. The average age was 41 years (median = 39 years), with 29% of people aged 26 to 35. Over 70% of respondents had completed at least an undergraduate degree and almost 25% had a postgraduate degree or higher qualification. The high proportion of respondents with a university qualification is indicative of the emphasis on wealthier consumers in the sample. The median household income was AUD$91,000; the lowest household income was AUD$20,800 and the highest AUD$286,000; about 45% of respondents had incomes of over AUD$100,000. Over 37% of participants had total assets (including the value of their residence, investment property, superannuation retirement savings, investment portfolio) of over AUD$1,000,000.

INSERT TABLE 3 ABOUT HERE

4.2 Modelling Respondents' Discrete Choice Behaviour

Our approach allows us to determine:

(1) the likelihood that an individual will choose a specific space tourism option based on the combination of the features offered,

(2) how this choice will vary based on the price and composition of competing options, and

(3) how this choice will vary based on the characteristics of the individual making the choice.

We first report the average number of choices in the experiment across all scenarios. This reveals the average likelihood of choosing one of the options independent of all specific features, but the averages do not reflect differences in survey responses when feature level combinations are varied. Overall, we see patterns consistent with expectations but well below the sorts of numbers reported in the non-experimental based studies described earlier.

The DCEs ask survey respondents to indicate their one most likely choice in each choice scenario (choice set) in the choice experiment. Respondents could choose one of the space tourism options, or indicate that they would choose none of the options. The first result that we report is the overall choice proportions for each of the options offered. In experiment 1, which focused on zero-gravity flights, high-altitude flights (the inferior option) attracted 35.2% of choices, zero-G flights attracted 14.8% of choices, and sub-orbital flights (the superior option) attracted 12.1% of choices. Almost 38% of all choices, however, were a choice of none of the options. In experiment 2, which focused on sub-orbital flights, zero-G flights (inferior) attracted 35.9% of choices, sub-orbital flights attracted 14.6% of choices and orbital flights (superior) attracted 11.9% of choices, with the choice of none of the options being 37.6% of the cases. It is worth noting that a number of scenarios offered respondents fairly attractive options that likely cannot be delivered at the quoted prices due to costs. So, the actual proportion of actual market choices of the three target space tourism options in the two experiments will be many times lower than the above figures suggest.

In order to capture tradeoffs involved in choosing among competing space tourism options, we developed several choice models. All choice models consist of two components, one systematic or predictable, and a second random or unpredictable. More specifically, the utility of a space tourism option can be decomposed into two components, systematic and random. Many different choice models can be derived by making different assumptions about the random component and/or distributions of effects in the systematic component.

For example, a well-known, simple choice model is the conditional logit model (also called a "multinomial logit model", or MNL model). This model is derived by making a strong assumption about the error component, namely that the errors are independently and identically distributed (i.i.d.) as extreme value type 1 random variates. This assumption leads to the well-known property of MNL models called the IIA property. "IIA" is an acronym for "independence from irrelevant alternatives", which refers to the fact that an MNL model is completely defined by the utility of pairs of choice options, with one of the options serving as a reference or “base” option. It is well-known that the simple MNL model is rarely ever consistent with real choices. For that reason, we do not discuss this model further, but the results of this model can be obtained from the authors on request.

We used the MNL parameter estimates as starting values to estimate more complex and realistic models known as random coefficient models. These models retain the i.i.d. error assumptions, but avoid the IIA property by allowing for a continuous distribution of effects (i.e., “utilities”) associated with each feature of each space tourism option. That is, these models recognise that feature effects can vary across respondents, and this variation is captured by hypothesising a continuous underlying distribution, typically a normal distribution. We specifically focus on and make use of so-called “mixed-logit” models (or, MIXL models), originally proposed by Revelt and Train (1998) (see also McFadden and Train, 2000).

Both experiments 1 and 2 vary a large number of features of the various space tourism options, which, in turn, requires one to estimate the mean and the associated standard deviation of many feature effects. In order to simplify the exposition, we first estimated a complete model for all possible feature effects, and then re-estimated the model after eliminating all effects that were not significant in the first model. The final results are in shown in tables 4 and 5.[3]

Prior to discussing the model results, we note one covariate measure is labelled ‘No. of risky engagements’ in the table of results, which refers to respondent answers to questions about activities that they could undertake. We identified a number of activities that are ‘risky’ and we used the total number of these activities that each respondent reported that they engaged in as a covariate (this measure ranges between 0 and 7). Respondents also

[3] Further detailed results are available in *(reference withheld for the purposes of the blind review).*

answered a series of questions about various types of things that they might own like fishing gear, bicycle, car, paraglider, motorcycle, etc. We targeted seven of these to indicate a risk-taking tendency, and created a second covariate that indicates how many they own (ranges between 0 and 7). This covariate measure is called “no. of risky things owned” in the results discussed below.

INSERT TABLE 4 ABOUT HERE

Before summarizing the findings from experiments 1 and 2, it is important to emphasize again the fact that these results indicate how respondents made trade-offs *between* the three space tourism options modelled in each experiment, as well as the option to choose none of the alternative flights. The results of experiment 1 (table 4) can be summarised as follows, based on the estimated mean effects of the feature levels:

1. High-Altitude Flights (HA): Price had a significant, negative effect on demand as expected. Thus a higher price for this option shifted demand, everything else constant, to the other two flight options and the ‘no-flight’ option. Respondents preferred low physical requirements for these flights. They also preferred an Australian national operator and would be deterred were the operator Russian. Males were significantly more likely to choose HA flights than females, and the probability of choosing HA flights decreased at an increasing rate with age. Less-educated respondents were more likely to choose HA flights, whereas well-educated respondents were significantly less likely to choose HA flights, with preferences shifting to the other available options. The more risky activities in which a respondent participated, the less likely they were to choose HA flights. That is, the more risk-active the respondent, the more likely they were to prefer the other available options.
2. Zero-Gravity Flights (ZG): Respondents were more sensitive to the price of ZG flights than HA. They preferred national operators from Australia, the UK and Japan and

disliked the prospect of operators from China and Russia. Low crowding within the aircraft is significantly preferred. Males were significantly more likely to choose ZG flights than females, and the probability of choosing ZG flights declined linearly with age. Respondents with bachelor degrees were significantly less likely to choose ZG flights, while the more risky things a respondent owned, the more likely they were to choose ZG flights.

3. Sub-Orbital Flights (SO): Price had a very large effect on choosing SO flights (larger than all other price effects). Respondents significantly preferred the maximum time spent experiencing weightlessness (10 mins). Males were very significantly more likely to choose SO flights than females and the probability of choosing SO flights decreased at an increasing rate with age. Respondents with advanced diplomas were much more likely to choose SO flights, while those with a high school education or less were much less likely to choose SO flights. The more risky things owned, the higher the probability of choosing SO flights. But, in contrast, the more risky activities in which one engages, the less likely they were to choose SO flights.

The standard deviation estimates of the mixed logit results of experiment 1 (table 4) can be interpreted as follows. If the mean estimates are precisely estimated, such that the associated standard deviations are less than the mean coefficients, there is a relatively low probability that the parameters in the sample have signs that differ from the signs of the mean effects. Many standard deviations are large and significant, which indicates considerable preference heterogeneity, implying that the basic MNL model does not apply. The ratios of the standard deviations of the three price estimates (HO, ZG and SO flights) to their associated mean price effects are 4.1, 3.3 and 1.2 respectively. The ratios for HO and ZG flights are large, indicating that there are positive price parameters for some people in the sample.

On average, respondents prefer an Australian national operator, but not a Russian operator for both HA and ZG flights; but the standard deviations associated with these effects indicate that about 26% of respondents are negative towards Australian operators, while about 34% are positive towards Russian operators. We earlier noted that males are more likely to choose HA, ZG and SO flights; yet, for all options the standard deviations are about five times the mean effect, indicating that roughly 60% male and 40% female are likely to choose the three options. Regarding the effect of age, the standard deviations are similar to the mean age effect, indicating low probabilities that age effects are positive. The standard deviation estimates also reveal that preference heterogeneity differs widely with the level of education. Also, the more risky things owned by a respondent, the more likely they were to choose any of the HA, ZG or SO flight options. For ZG and SO flights, there was a low probability that the sign of the mean effect is reversed for some respondents, but in the case of HA flights, the standard deviation is about 3 times the mean effect, indicating wide variability in preferences for this option.

INSERT TABLE 5 ABOUT HERE

The results of experiment 2 (table 5) can be summarised as follows based on the estimated mean effects of the feature levels:

1. Zero-Gravity Flights (ZG): Again, price has a significant negative effect, although the effect is less than that found in experiment 1. Respondents significantly preferred Australia and Germany as national operators over the USA and China. The probability of choosing ZG flights decreased at an increasing rate with age. In terms of the effect of education, respondents with an advanced diploma were significantly more likely to choose ZG flights over the other options. The more risky activities in which a respondent participated, the less likely they were to choose ZG flights, being more inclined instead to shift preference to OR flights.

2. Sub-Orbital Flights (SO): Price had a significant negative effect on demand, but the effect is again lower than was found in experiment 1. However, the relative ratio of the price effects for ZG and SO flights was approximately the same in both experiments (i.e., ZG is about 25% of SO's price effect). Again, respondents strongly preferred the prospect of an Australian operator over one located in Russia. They preferred limited required training over extensive training. Males were very significantly more likely to choose SO flights than females and the probability of choosing SO flights decreased at an increasing rate with age. More educated respondents were less likely to choose SO flights than less educated respondents. The more risky activities in which a respondent participated, the less likely they were to choose SO flights over the ZG and OR flight options.
3. Orbital Flights (OR): The primary driver of OR flight choices was price, and this effect was very large and negative. There was a marginally significant preference for an OR flight service available now compared with one several years in the future (respondents may have believed they would be less able to make such a trip as they age). The probability of choosing OR flights decreased at an increasing rate with age. Better educated respondents were significantly less likely to choose OR flights than less educated respondents. The more risky things that a respondent owned, the more likely they were to choose an OR flight.

The standard deviation estimates of the mixed logit results of experiment 2 can be summarised as follows. The standard deviations of the price estimates with respect to their associated mean effects are 6.6 (ZG), 1.4 (SO) and 0.88 (OR). This indicates a large amount of heterogeneity in responses to ZG flight prices, but little heterogeneity in responses to SO and OR flight prices.

In the case of ZG flights, respondents preferred Australian and German operators; the associated standard deviation estimates imply that only 9% were negative towards an

Australian operator, but 32% were negative towards German operators. Although the mean effects are negative for US and Chinese operators, about 40% of respondents would be likely to choose US operators, but only 27% would be likely to choose Chinese operators. For SO flight options, little heterogeneity was indicated in preferences for Australian and Russian operators because the associated standard deviations are low (or zero) and were hence not significant. Sixty percent of males and 40% of females were likely to choose SO options. Respondents who engaged in more risky activities were more likely to choose OR flight options (70% are positive; 30% are negative), and these ratios declined for SO flights (58% are negative; 42% are positive) and ZG flights (96% are negative; 4% are positive).

Tables 4 and 5 report the findings for the flight features listed in table 1 which were found to have a statistically significant effect on choice. In experiment 1, the degree of risky activities had broadly a negative impact on choice. This result is counter-intuitive. It could be a statistical artefact or it could suggest that either those people who are more engaged in risky activities are either more aware and more conscious of the risks involved in space flight, or have any need for risky behaviour met through their existing activities. In experiment 2 the results did, however, show that other risk-taking activity was associated with increased choice for orbital flights. Age was associated with a consistent negative impact on choice across all forms of space tourism in both experiments. Although older people tend to have greater disposable income and are, therefore, in general, more able to afford the cost of space tourism flight options, their increased risk aversion and conservatism with age appears to more than offset the effect of their spending power. They may also believe that their level of fitness makes them less-suited to the rigors of space flight.

5. Conclusions

5.1 Space Tourism Choice Behaviour

This study confirms the implied assumption of previous research that potential space tourism customers are likely to be highly sensitive to price. The findings also show that there is considerable heterogeneity between respondents in terms of how they are likely to react to price when choosing between the different types of space tourism. The research also points to the significant role of other potentially important demand determinants. In terms of the features of a space tourism product, prominent determinants included the nationality of the operator (which may also have served as a proxy for other factors related to quality, risk, and convenience), the physical requirements placed on passengers, the level of passenger space or crowding, and the extent of pre-flight training required. Among the characteristics of the potential customer, gender, age, education, and the extent of other risk-taking behaviour typically played an important role in influencing choice.

The results of this research indicate broadly that there is a significant portion of the public, in general, and of high-income/high-net-worth individuals in particular, who are favourably disposed toward engaging in some form of commercial space tourism flight activity. There are several different alternative forms of space tourism possible and, within each, there is likely to be a growing number of competing space tourism ventures to emerge over time. It has been observed in the early years of other 'new' industries, when the way forward is clouded by uncertainty – uncertainty in regards to: customer choice behaviour and preferences, technological foundations, and the dynamics of cost – that enterprises search for the best 'business model'. At some point, however, typically such new industries undergo a shake-up during which a number of the early entrants exit the market as the business model they adopted turned out ultimately to be uncompetitive. Competitive business models for space tourism will comprise those which provide the right trade-off between what customers most desire, and what technology is capable of delivering, at a price (and cost) that can keep pace with the declining cost of competitor operations as economies of scale unfold and as learning effects accumulate.

Understanding what customers desire will, therefore, be a key ingredient to success. Although the scope of this study is modest, it has demonstrated that the tools for investigating this are available. Further ongoing research into space tourism consumer choice behaviour is bound to become a critical, continuous need as commercial space tourism unfolds in the years ahead. As experience from the commercial civil aviation industry analogue of the 20th century demonstrates, changes in technology, competition, the economy, society, legal and regulatory frameworks, demography, and the environment will necessitate many such consumer studies in the long run.

5.2 Implications for Space Tourism Marketing and Commercial Development

Having demonstrated that private, commercial space tourism operators are capable of designing and building a sub-orbital space craft, the space tourism industry now faces questions about how to sell technological space flight solutions to potential consumers. Thus accurate marketing research is crucial for designing commercial space tourism experiences based on sound understanding of likely future consumer choices.

The industry faces a major challenge in conducting sound, reliable, state-of-the-art research for a product with no history, numerous potential product configurations and little consumer understanding of risks and benefits. Our empirical results show that one can potentially overcome the challenges to estimate a good first approximation to the potential demand for space tourism based on sound theory and methods.

We were able to deal with the challenges by addressing several issues. Firstly, we avoided the ambiguity and open-endedness of previous research in which respondents were not required to make tradeoffs. Second, we used well-tested theory and methods to model and predict demand for space tourism by using information acceleration methods to inform and educate respondents about the features of space tourism products and services; and we modelled the resulting choices with state-of-the-art discrete choice models. The use of a robust multimedia platform allowed us to execute the IA experiments fast and economically, which allowed us to integrate multiple layers in our experiments. In turn, this allowed us to simulate various market contexts as realistically as possible. Finally, we took advantage of recent advances to examine the evolution of customer choices as the market develops by using dynamic experiments.

5.3 Limitations and Future Research

The findings of this research are limited in several important ways. The respondents were derived from an Australian sample. It is evident that this factor likely significantly affected the findings concerning the impact of the nationality of the space tourism operator, in that an Australian operator was preferred. Other findings might also differ in other national contexts. The choice scenarios presented to each survey respondent focused on the choice between space tourism types rather than the choice that might occur within each particular type. However, the general approach adopted in this study could easily be translated to a study, say, of customer choice between different products offered by various sub-orbital competitors. In order to limit the possible combinations of product types and features – which would have resulted in inordinately large and intractable choice experiments – the research restricted the number of features modelled for each of the ‘inferior’ and ‘superior’ options.

The choice experiments examined a large number of product features across the four different types of space tourism studied. Future space tourism DCEs could investigate the influence of certain product features, or combinations of features in more focussed detail. Through the application of Information Acceleration methods, we were able to make use of various media to inform respondents about the hypothetical options available in the survey. There is much greater scope, however, to investigate the role of information search, and uses of, as well as preferences for, different forms of information and their influence on customer choice. From a marketing strategy perspective, discrete choice experiments offer a broad and flexible means of investigating conceivably many of the factors that are likely to be of interest to space tourism enterprises.

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