

COMPETITION ON THE BASIS OF SAFETY?

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Abstract

Safety is arguably the most important “quality” attribute of commercial aviation, yet it rarely figures into overt inter-firm rivalry. This chapter lays out the underlying economic models of safety provision and the demand for safety by passengers, and concludes that profit maximizing firms should seek to diversify their safety offering. However, crucial failures in market processes remove the desirability to diversify and lead to minimal product differentiation among mainstream airlines. That said, the chapter concludes by pointing to two examples of competitive markets where there are actual or imagined differences in safety between the rival airlines.

Keywords: aviation, safety, competition

1. INTRODUCTION

Safety is arguably the most important “quality” attribute of commercial aviation, yet it rarely figures into overt inter-firm rivalry. Usually, airlines do not even allude to their safety record vis-à-vis rivals in their advertising and press statements. Moreover, statistical analysis by independent parties usually indicates that peer airlines within the same geographic region and segment of the industry have indistinguishable safety records (Barnett, 2010).

Of course, airlines and their trade associations are never shy about touting the continued decade-over-decade improvement in safety, and the lower level of risk inherent in air travel compared with land-based forms of transportation. However, this chapter does not focus on time-series or cross-modal comparisons, but rather it considers cross-section differences between individual airlines.

The lack of differentiation between airlines might seem to be somewhat surprising. One might imagine that some airlines might find it profitable to seek to gain a market advantage over their rivals by offering exceptionally high, or low, levels of safety. Indeed, as we will describe in the first part of the chapter, microeconomic theory predicts that firms will prefer to offer a different level of quality from their rivals because it reduces the intensity of price competition, and allows for the earning of supernormal profits.

Clearly, airlines have generally not elected to adopt such a strategy. Why is this? The chapter answers this question by describing the conditions that are necessary for a market outcome characterized by a diversity of safety offerings, and critically evaluating whether these conditions hold in practice. We will show that some prevalent market failures, including poor information, lead to a lack of incentives for airlines to diverge from the pack in their safety offerings. Airlines conclude that passengers would not notice that a greater-than-average level of safety is being offered, and thus would be unwilling to pay a higher price to obtain it.

That said, there is often a fear that poor information flows might lead some airlines to, either intentionally or unintentionally, exploit passengers by providing less safety in the short run while still representing themselves to passengers as providing mainstream levels of safety. The chapter describes the theoretical and empirical literature dealing with this type of behavior.

The main thrust of the chapter is to provide a theoretical and empirical understanding of why there is usually minimal safety differentiation. However, this is not always the case. The chapter concludes by pointing out that there are, at least, two examples of types of markets where there is overt rivalry that involves actual or imagined safety differences.

2. A MODEL OF SAFETY RIVALRY

To motivate and frame the discussion, let us consider a stylized model of safety determination and safety rivalry. The aviation industry will be taken to be composed of a network containing many different city-pair markets, which we will call “routes.” Individual routes will be denoted by the subscript j . The industry as a whole has multiple airlines

competing within it. Individual airlines will be denoted by the subscript k . In practice, not every airline serves every route and there are usually few rivals on each route. Indeed, in some “thin” markets there may be only one airline offering service. The implication is that the most applicable economic models to consider are those describing oligopoly or monopoly.

2.1 Airline Passengers

There are numerous potential consumers of airline service. We will denote individual consumers by subscript i , and indicate the subset of these consumers who might travel on each route by the subscript ij . We will assume that each consumer buys at most one unit of travel (a trip on a given route) in each time period. For the sake of illustration that time period can be taken to be one calendar day.

In deciding whether to take an airline trip on route j , and deciding which airline to patronize (in the event that there is a choice), the consumer takes the following variables into account:

B_{ij} The net benefit from taking the trip by air relative to undertaking the trip by the next best alternative mode. If there is no practical alternative mode, this is simply a measure of the utility obtained by the consumer at the trip’s destination relative to the next best use of the consumer’s time. This is independent of the specific airline used.

p_{jk} The fare charged by the various airlines.

F_{jk} The vector of departure times offered across the day by the various airlines. Consumers will have a preferred departure time, and will gravitate (all other things being equal) to the airline that offers the least “schedule delay” or deviation from their preferred time (see Panzar, 1979).

$\alpha_j(1-S_k)$ The probability of an incident on a given flight. We will argue in a few moments that each airline will determine an underlying level of safety (S_k) that will be common to every route that it serves. In addition there may be some route specific safety factors, such as flying in difficult terrain or serving a poorly-equipped airport, that are common to all airlines serving the route. This exogenously-determined route-specific factor (α_j) can be thought of as a proportionate deviation from the risk on the “average” route.

T_{jk} A vector of other quality attributes (such as seat pitch, and in-flight amenities). While many of these quality attributes will be the same for an individual airline on each route its serves, such as the nature of its frequent-flier program or the responsiveness of its customer service, others will vary by route due to considerations of whether it is a short-haul or long-haul flight.

Frequency, safety and aspects of quality are examples of “vertical” product attributes in that all passengers would agree that “more is better” but they may vary in their strength of taste

for these attributes. We will specify a convenient separable, quasi-linear form for a utility function. Specifically, presuming that the consumer i decides to travel, and patronizes airline k on route j , she will have a utility from taking the trip given by:

$$(1) \quad U_{ijk} = B_{ij} + \beta_{ij} F_{jk} + \gamma_{ij} T_{jk} - \theta_{ij} \alpha_j (1 - S_k) - p_{jk},$$

where β and γ indicate a consumer's individualized valuation of frequency and other quality attributes, respectively, and θ measures the individualized (dis)utility from involvement in a crash.

The consumer will evaluate their utility using equation (1) for every airline serving route j , and select to travel with the airline that provides the greatest net utility. In the event that the utility given by equation (1) is negative for all airlines offering service, the consumer will decide not to undertake an airline trip and either take the next best alternative mode or make the next best alternative use of their time. We will define the demand that each airline receives on a route as q_{jk} . The nature of the determination of demand will be given in the next section but one.

2.2 Airline Costs

Each airline has a total cost function for its entire network defined as:

$$(2) \quad TC_k = \sum_j c(q_{jk}, F_{jk}, S_k, T_{jk}).$$

Total cost is assumed to be increasing in q , F , S and T . There is a positive marginal cost of serving an additional passenger, running an additional flight or increasing amenities. The safety variable deserves some additional analysis.

Safety-related costs are incurred at two points. First, the airline has to incur the cost of the “preventive effort” undertaken to ensure a given level of safety. Preventive effort has to be expended each time period. Airlines can reduce the probability of a crash by hiring higher-quality pilots, providing them with more training, ensuring that they do not become fatigued, purchasing more safety features for their aircraft, and making sure that the aircraft are properly maintained.

In practice economies of scope and scale in the production of safety and the interoperability of equipment and staff between routes, mean that an airline has to decide on the level of safety at a network level and not on an individual route level. Consequently we will be just defining S_k and not S_{jk} (remember that any idiosyncratic exogenous route-level safety factors common to all airlines are measured by the variable α_j). We will define the *unit* per-flight-departure safety prevention costs as an increasing convex function of the level of safety, and denote it as $e(S_k)$.

The second point at which costs may be incurred is when a crash occurs. These “crash costs” include (from the perspective of the airline): aircraft damage, lost staff productivity and staff medical expenses, and all exogenously-defined legal responsibility for compensating injured passengers, cargo shippers, and any bystanders on the ground. In addition, there will be

the discounted value of future financial consequences such as increased insurance premiums, reduced revenues if some passengers shun the airline, and any increased capital costs arising because the airline's stock is less attractive.¹

We will denote the amount of damages in a typical crash as D . (Because a crash will occur at a random location these damages will be based on an average passenger load factor and will affect an average number of bystanders on the ground.) For the sake of clarity of discussion, we will assume that while the probability of a crash occurring, $(1-S)$, is endogenously determined, the consequences are exogenously determined. In reality, airlines can also choose to invest to mitigate the consequences in the event that an untoward incident occurs. Phillips and Talley (1992) empirically show that investments in pilot training and safety equipment can reduce the expected severity of a crash.

For any given flight on a route with average exogenous safety factors (i.e, $\alpha_j=1$), an airline will have an *expected* safety cost, denoted by ESC , given by:

$$(3) \quad ESC(S) = e(S) + (1-S) D .$$

This function and its components are illustrated in Figure 1. The level of safety is shown on the horizontal axis, with low levels of safety at the left hand end and high levels of safety at the right hand end. As a consequence of the linear nature of the crash cost function and the convex nature of the prevention cost function, the expected safety cost function takes on a "U" shape. Expected costs are minimized at S^{min} . This point is defined by the first order condition:

$$(4) \quad \partial ESC / \partial S = e'(S) - D = 0$$

** FIGURE 1 HERE **

At the cost-minimizing level of safety, the slope of the prevention cost curve is equal to the damages suffered in a crash (the latter is the slope of the expected crash cost function in Figure 1). Rational airlines would never offer safety of less than S^{min} because they could simultaneously lower their costs and increase their attractiveness to passengers by offering a higher level of safety. Therefore the only part of the cost function for safety that would normally concern us is the portion that is upward sloping in the range $S^{min} \leq S \leq 1$.

2.3 Consumer Choice

This section will illustrate the nature of a consumer's choice. To do so, let us consider the case where there are just two airlines serving a route. One airline, that we will denote by the subscript $k = H$, offers a high level of safety, and the other, denoted by the subscript $k = L$, offers a lower level of safety. For simplicity, let us assume that we are dealing with a typical route, so that $\alpha_j = 1$. We will not concern ourselves at this point with the industrial organization aspects of why there are just two airlines on this route, and how they selected their respective levels of

¹ The effect of crashes on demand will be discussed later in the chapter. For evidence on the, seemingly limited, long term effect on stock prices see Chance and Ferris (1987), Mitchell and Malony (1989), the review by Rose (1992), Bosch, Eckard and Singal (1998), and Kaplanski and Levy (2010).

safety and prices. The choice of safety level and price is the focus of the next section of the chapter. We will just specify that $p_{jH} > p_{jL}$. This assumption makes sense because we know that the high safety airline incurs greater costs than the lower safety airline, and moreover the lower safety airline would be unable to attract any passengers if it offered worse safety and a higher fare.

It is clear that we have a multi-dimensional problem in that the airlines are not just competing on the basis of safety, but also in terms of the frequencies they offer, and the other quality attributes. As this is a chapter dealing with safety, we will assume for the sake of illustration that both airlines are offering the same set of departure times, and identical non-safety-related service quality. By doing so we can simplify equation (1) by defining a new variable, v_{ij} , that represents the valuation of the non-safety aspects of the trip:

$$v_{ij} = B_{ij} + \beta_{ij} F_{jk} + \gamma_{ij} T_{jk} .$$

If a consumer decides not to fly, denoted by subscript $k = 0$, he will earn a utility of:

$$(5) \quad U_{ij0} = 0.$$

If he flies on the high safety airline, his utility will be:

$$(6) \quad U_{ijH} = v_{ij} - \theta_{ij} (1 - S_H) - p_{jH} ,$$

and if he flies on the lower safety airline, his utility will be:

$$(7) \quad U_{ijL} = v_{ij} - \theta_{ij} (1 - S_L) - p_{jL} .$$

We define that $v_j \in [v_j^{min}, v_j^{max}]$ and distributed according to a known function. The valuation of crash involvement $\theta_j \in [\theta_j^{min}, \theta_j^{max}]$ is also distributed with a known function, which will be taken to be independent of the function describing the distribution of v_j . Consequently the set of possible consumers looking for airline service on route j is represented by the rectangular space illustrated in Figure 2. Consumers located in the top right hand corner of the rectangular space have a high valuation of the non-safety aspects of the trip and have a high valuation of safety (which is to say they incur a relatively large disutility from involvement in a crash).

** FIGURE 2 HERE **

We can define the point where consumers are indifferent between the high and low safety airlines by setting equation (6) equal to equation (7). Rearranging this equality produces the critical value, θ_{jLH} for which consumers are just indifferent:

$$(8) \quad \theta_{jLH} = \frac{p_{jH} - p_{jL}}{S_{jH} - S_{jL}}$$

Consumers with larger values of θ_j prefer to travel with the high safety airline rather than that the low safety airline, regardless of their value of v_j .

Equating equations (5) and (6) and rearranging terms yields the following boundary condition characterizing the values of v_j and θ_j for which consumers are indifferent between traveling with the high safety airline and not flying:

$$(9) \quad v_{j0H}(\theta) = p_{jH} + (1-S_H) \theta_j .$$

For any given value of θ_j , consumers with a v_j greater than $v_{j0H}(\theta)$ prefer to travel with the high safety airline rather than not flying. Similarly, we can define:

$$(10) \quad v_{j0L}(\theta) = p_{jL} + (1-S_L) \theta_j .$$

For any given value of θ_j , consumers with a v_j greater than $v_{j0L}(\theta)$ prefer to travel with the low safety airline rather than not fly.

These boundary conditions are plotted in Figure 2.² We can now determine the consumption choices of individual consumers whose (v_j, θ_j) values lie in different regions of the figure. Consumers in regions III and IV fly with the high safety airline. Consumers in regions I and II travel with the low safety airline. Consumers in regions V and VI choose not to fly.

The implication is that provided the conditions are met for this market to operate, both high and lower safety airlines can coexist in the same market, and both can receive positive demand. Indeed, one could extend this model so that three or more different safety levels may exist on the same route.

3. AIRLINES' CHOICE OF SAFETY AND PRICE

Let us now explore how airlines might select their level of safety, and the prices that they charge. While it is not very realistic, the natural starting point is the benchmark case of the safety choices and prices that might exist in a first-best world. We will then consider more realistic models of inter-firm rivalry. We will contrast cases where the airlines provide similar level of safety, and cases where they differentiate their product. To compare these various market structures in the clearest possible way we will make three simplifications. First, we will take it as understood that we are focusing on just one route, which will allow us to drop the subscript j . Second, all consumers will have identical values of v_i , which we will just denote as v . Third, we will assume that the N total consumers are distributed in a uniform distribution over the range $[\theta^{min}, \theta^{max}]$.

In the first-best world, every single level of safety in the range $S^{min} \leq S \leq 1$ is made available, and the price per passenger is driven to cost. We denote the latter as $c_q(S)$, where the

² For the diagram to look like figure 2 we are assuming that $\theta_j^{min} < \theta_{jLH} < \theta_j^{max}$.

cost per passenger is an increasing convex function in S . Each consumer's utility will be given by:

$$(11) \quad U_i = v - \theta_i(1-S) - c_q(S).$$

The consumer will only choose to fly if equation (11) is non-negative.

Let us assume at this point that v is sufficiently large that not only do all consumers purchase at first best, but all do so when, as is described later in the section, airlines price above cost. The first order condition indicates that the consumer's utility maximizing, or "preferred," level of safety, which we will denote as S_i^* , is defined when the marginal cost of providing additional safety equals that consumer's value of θ . It is worth emphasizing that this is a consumer's preferred safety level under the assumption that price is driven to cost. The first order condition will produce a monotonic mapping from various consumers' θ_i to their value of preferred safety level S_i^* . Consequently consumers will be uniformly distributed in the range $[S^{*min}, S^{*max}]$. We will take this to be contained within the range $[S^{min}, 1]$, which is the feasible range the airlines would be prepared to provide.

While interesting as a reference point, this is clearly not of practical relevance to commercial aviation which is a lumpy product in that a large number of passengers share the same flight.³ Therefore, not every consumer will be provided with a level of safety that is tailored to their exact tastes. At best we will be in a world of monopolistic competition described by Dixit and Stiglitz (1977). In their model there is a fixed cost associated with production which leads to less variety of products than exists at first best. This would seem to be particularly relevant to the airline industry where there is a sunk cost associated with operating a flight with a negligible marginal cost for each additional passenger conveyed.

In practice we find that there are even fewer firms in the airline industry than is typically consistent with a model of monopolistic competition. The airline industry is more closely characterized by oligopoly models. Let us contrast some duopoly models. Initially we will look at models that have minimal (i.e., zero) safety differentiation and then we will look at models that predict a large amount of differentiation.

Models of minimal differentiation might be associated with conditions in the pre-deregulation airline industry when price was determined exogenously and was common to both airlines. The famous model of Hotelling (1929) has duopoly firms competing to obtain the largest market share. In this model, airlines do not compete on price but try to attract passengers by providing a level of safety that is closer to an individual passenger's tastes than the level of safety offered by their rival airline. The dynamics of this model are that each airline is attracted closer and closer to the middle of the distribution of passenger tastes in an attempt to "steal" passengers from the other airline. The ultimate equilibrium is for both airlines to locate exactly in the middle of the distribution, which we might designate as safety level S_M , and they share all the traffic equally between them.

³ This model may, however, be ideal for thinking about the safety of general aviation.

To extend this example, let us consider a market in which price is now endogenous but both airlines have the same exogenously predetermined safety level S_M . The airlines now compete vigorously on price in a Bertrand fashion, and price gets driven down to cost, and neither airline earns a profit.

If we now allow both safety level (in the first stage of a game) and price (in the second stage of a game) to be endogenous, we find that the duopolists have strong incentives to diverge in their safety offerings in order to lessen price competition (see Shaked and Sutton, 1982). Let us look at the second stage of the game after the two airlines have differentiated their product and offer safety levels S_H and S_L . Assuming that v is sufficiently large that all consumers decide to fly, the dividing point in the uniform distribution of consumers between θ^{\min} and θ^{\max} that will determine the market share of the two airlines is given by equation (8). Therefore the profit function for the high safety airline is given by:

$$(12) \quad \pi_H = (p_H - c_q(S_H)) \frac{\left(\frac{\theta^{\max} - p_H - p_L}{S_H - S_L} \right) N}{(\theta^{\max} - \theta^{\min})} .$$

The first part of the term on the right hand side is the price-cost margin, and the second part of the term is the demand for this airline indicated by the total market size, N , multiplied by the proportion of the consumers whose taste in safety is greater than the indifference point given by equation (8). There is a similar profit function for the low safety airline given by:

$$(13) \quad \pi_L = (p_L - c_q(S_L)) \frac{\left(\frac{p_H - p_L - \theta^{\min}}{S_H - S_L} \right) N}{(\theta^{\max} - \theta^{\min})} .$$

We will make the normalization that $N=1$, and $(\theta^{\max} - \theta^{\min})=1$. Both airlines maximize their profits with respect to the price that they charge. Differentiating equations (12) and (13) with respect to an airline's own price, and making a Cournot-style assumption that the other airline will not change its price in response to a price change by the first airline, produces a pair of reaction functions. The intersection of these reaction functions defines a Nash equilibrium in prices. The equilibrium price charged by the high safety airline is given by:

$$p_H = \frac{1}{3}(2c_q(S_H) + c_q(S_L)) + \frac{1}{3}(2\theta^{\max} - \theta^{\min})(S_H - S_L) ,$$

and the price of the low safety airline is given by:

$$p_L = \frac{1}{3}(c_q(S_H) + 2c_q(S_L)) + \frac{1}{3}(\theta^{\max} - 2\theta^{\min})(S_H - S_L) .$$

Some additional manipulation of these two price definitions produces a number of powerful conclusions. The first is, as one would hope, the price charged by the high safety airline is higher than that of the low safety airline (if this was not the case the low safety airline would receive zero demand). Second both airlines make positive profits, so both of them are better off than offering an identical S_M and competing vigorously on price. Third, the price-cost margin for the high safety airline is larger than that for the low safety airline. Fourth, as indicated by the final parenthetical terms in both price equations, the profit margins for both airlines get larger the more differentiated their products. This implies that in the first stage of the game where the airlines choose their safety level they should differentiate their products as much as is possible.

4. CONDITIONS FOR A DIFFERENTIAL SAFETY LEVEL TO EXIST

The implication of the previous section is that airlines should attempt to differentiate themselves as much as possible from their rivals because it softens the price competition between them. In reality, the stereotype of commercial aviation is that all the mainstream airlines seem to be offering similar levels of safety. Why is this? For the market to produce differentiation, it has to meet certain conditions. Let us list these conditions, and assess their validity for commercial aviation.

4.1 A Diversity of Consumer Tastes for Safety

The model described in the previous section requires a sufficient amount of consumer heterogeneity. Specifically, θ^{max} has to be approximately twice as large as θ^{min} . The low safety airline will only make non-negative profits if:

$$(14) \quad \theta^{max} - 2\theta^{min} \geq \frac{C_L - C_H}{S_H - S_L}.$$

One will note that the numerator of the right hand side is negative, so it is possible that θ^{max} could be less than twice as large as θ^{min} , but only by the amount given by the ratio on the right hand side. If there is insufficient diversity, the low safety airline will make negative profits and withdraw from the market.

Expressed in a more intuitive way, in the event that the range $[\theta^{min}, \theta^{max}]$ is very small, or even if the range was larger but the preferences of nearly all of the consumers were not uniformly distributed but were tightly packed together, then we would expect that airlines would offer a similar level of safety. Airlines will locate where the passengers are, and if the passengers all have broadly similar valuations then airlines will tend to offer broadly similar levels of safety.

To my knowledge there are no papers or reports that have conducted surveys to measure inter-passenger variation in the value placed on safety, or conducted revealed or stated preference tests from which one could infer such a variation. However, one would imagine that the variation in risk/price trade offs that consumers display in their purchases of other products

carries over to the airline markets. Some consumers are willingly purchase less safety features for their automobiles, or purchase older models with less safety features, or decide to replace their tires less often in order to save money. Some consumers prefer to ride bicycles without helmets while others do not. Some people jaywalk when crossing the street while others walk a longer distance to cross the road at a recognized crosswalk. Therefore, I would imagine that a similar variation exists for commercial aviation.

4.2 Consumers Know the Safety Level(s) Offered by Airlines

The general requirement for most economic models to function correctly is that consumers need to be fully informed when they make their consumption choices. For some aspects of the airline product, such as fare, schedules, seat pitch and in-flight amenities, passengers can quite easily collect information so as to make informed choices. In contrast, the underlying probability of a crash for a particular airline is less easy to observe. Indeed this probability is difficult for even safety professionals to know (see, for example, the paper by Chang and Yeh, 2004, which attempts to define an index to measure safety). We will argue later that even an individual airline really cannot quantify its own safety posture in any definitive sense, although it can make a better informed judgment than can passengers. The asymmetry of safety information between airlines and passengers is a classic market failure.

Of course, one would not expect passengers will be totally uninformed. The industry's and an individual airline's safety mishaps are public knowledge and thus passengers can get information from the press and other sources including official government databases. Consequently, even somebody who has never flown before can form some knowledge. In economic parlance, aviation is "search good" rather than an "experience good" whose quality can only be assessed by consumption (Nelson, 1970). While one would imagine that frequent fliers do collect observations and experiences to update their safety perceptions, the fact that safety is a probabilistic attribute means that it cannot be assessed on every trip (Shapiro, 1982). Indeed the trip on which you learn that your chosen airline displays a low level of safety may be your last.

There is a small literature that empirically investigates whether an airline's safety performance is correlated with other quality attributes that may be more readily observed. Rhoades and Waguespack (1999) were unable to find a correlation between complaints about service made to the federal Department of Transportation and a broadly-defined measure of safety for nine major United States airlines for the period between 1991 and 1997. However, they did find a positive correlation – more complaints about service are associated with more safety incidents – for a sample of 21 regional airlines over the same time period (Rhoades and Waguespack, 2000). Martin and Román (2010) conclude that there is such a correlation for even the largest ten airlines in the United States, but their data is for only one year, and that year was the tumultuous 2001.

It is beneficial to separate consideration of passengers' knowledge of safety level into two parts. The first is whether passengers can form an accurate evaluation of the general safety level of the industry. The second is whether they can differentiate between the safety offered by various airlines within the industry.

There has been a literature dating back more than thirty years that explores how people form perceptions of risk. In particular, psychologists have found two systematic biases (Lichtenstein et al., 1978). The first, termed primary bias, is the tendency to overestimate infrequent causes of death and to underestimate more frequent causes. The “crossover” point where perception and reality are closest is for risks that claim 300-500 per 100 million Americans a year, such as syphilis and hypothermia. The fatality count for commercial aviation is considerably smaller. The upward primary bias is compounded by a secondary bias. Hazards with an upward secondary bias are generally dramatic and sensational, whereas hazards with downward secondary bias tend to be unspectacular events that claim one victim at a time. The receipt of information from the media was also found to influence the judged frequency, and the frequency of newspaper reporting usually has little to do with the actual frequency of that risk in the community (Combs and Slovic, 1979). Barnett (1990) illustrates that aviation crashes generate a disproportionate level of coverage by the media relative to other common risks in society.

The consequences of this general tendency to believe that aviation crashes happen more frequently than they actually do can be examined in a simple model of monopoly. The general result is that the upward misperception will lead airlines to provide *less* than the optimal level of safety. This somewhat counterintuitive result emerges because passengers do not fully incorporate into their demand functions the “benefits” of the preventive actions taken by the airlines (Spence, 1977).

However, there is another effect that works in the other direction. Psychometric researchers have also asked respondents to rate acceptance of risks based on various characteristics. Because most of these characteristics are collinear with each other, factor analysis has been used to boil these down to two major factors. The first is whether the probability and consequences of a risk are known in advance and generally understood. This is referred to as the “unknown factor.” The second is that certain types of risk engender “dread.” The dread factor is an amalgam of various risk attributes including whether the victim is exposed involuntarily, whether the outcome is likely to be fatal, whether the risk involves a nasty drawn-out form of death, and whether the consequences can be mitigated by the diligence or skill of the victim when a risky situation occurs. Researchers have found that the higher the unknown or dread rating of a risk, the more that society is intolerant of it.

In Fischhoff et al.’s (1978) analysis of 30 common risks, commercial aviation was found to have a close to average unknown score, but the largest dread score. Indeed the dread score was considerably larger than that assessed for handguns, motorcycles, or working in the construction industry. The extremely high dread score resulted from respondents feeling that an aviation crash was certain to have fatal consequences, and that the victim could not personally mitigate or escape from the any dangers that arise. Clearly, being strapped into a seat in a confined aluminum tube miles above the earth is considered to be very disconcerting in the event that an emergency occurs. The implication is that the values of θ for aviation will tend to be very much larger than is the case for, say, automobile travel. Consequently, we would expect that the market would work to provide very high levels of safety in this industry. So perhaps it is not surprising that aviation is statistically the safest mode of transportation.

The situation becomes more complicated in competitive markets with product differentiation where passengers not only have to have some idea of the general safety level of aviation, but also have to be able to distinguish between the safety records of individual airlines. Theoretical models show that in the extreme, if passengers were unable to distinguish on the basis of safety between airlines, then no airline would choose to supply a high-safety service because passengers would not recognize the service and would be unwilling to pay a higher price to obtain it (Akerlof, 1970). In effect there will be a “race for the bottom” as all airlines reduce costs by moving to offer S^{min} .

This extreme situation does not seem to apply in practice, however. Not all airlines seem to offer the bare minimum in terms of safety. In part this may be because while passengers may not be able to differentiate between many airlines due to a lack of information, they can recognize a “notorious” airline and act accordingly. Klein and Leffler (1981) argue that consumers are aware of the underlying costs of production and can thus calculate a “quality assuring price.” Firms charging less than this amount cause consumers to suspect that a shoddy product is being offered. An alternative explanation is advanced by Rogerson (1983) who argues that firms with poor quality services tend to have more dissatisfied customers than firms offering high quality service and “word of mouth” may signal to other consumers which firms are notoriously bad.

It would be an interesting research project to determine how and why an airline may acquire a notorious reputation. Is there a “tipping point” or a critical number of crashes that has to occur in a given period of time for an airline’s reputation to change? Are there certain types of information that might be revealed that are particularly damaging to a reputation?

There is some literature that empirically investigates whether the information provided by a crash is incorporated into demand decisions. Borenstein and Zimmerman (1988) using United States data from 1960 to 1985 find that crashes do lead to a decline in demand for the crash-involved airline, but that the effect is temporary and equivalent to about 10-15% of one month’s demand volume.⁴ Wong and Yeh (2003) found similar results using data from Taiwan for the period from 1981 to 1999. The monthly demand loss was about 22% with a duration of two-and-a-half months on average. Interestingly, while some of the lost passengers may decide to travel on rival airlines, there is also a dampening effect on the demand for air travel in general with the demand for other airlines declining temporarily by 5%. Of course, set against these general findings of limited demand response, one could point to specific examples of airlines with notoriously poor records having been forced to contract or exit the market, or passengers’ shunning specific models of aircraft.

It is attractive to argue that passengers can probably identify notoriously poor airlines, but they are probably less sure about the safety rankings of more mainstream airlines. This is primarily because crashes occur with (fortunate) rarity for individual airlines, making recent press coverage an unreliable indicator for making demand decisions. Moreover, those crashes that do occur often are caused by a bizarre set of circumstances that makes it unclear whether passengers should infer that the airline was at fault or instead blame the weather, an “act of God,” or pure

⁴ This literature does suffer from the problem that a crash-involved airline may have to temporarily reduce its fares which would mean that the demand response to a crash may be understated.

bad luck. More definitive inter-operator safety data, such as the number of pilot deviations or the number of engines shut down in flight, can be difficult to obtain and interpret. Information on the underlying determinants of safety such as staff training and maintenance procedures are generally not available. Even if they were, the link between the magnitude of these inputs and actual safety performance is a mystery even to safety professionals.

The situation is made worse because it is regarded as somewhat unseemly for airlines to advertise that their crash rate is better than that of their competitors. It may also be counterproductive in that highlighting an essentially negative aspect of aviation may reduce the demand for all airlines. At best airlines have to use code words to communicate to potential passengers that they are supplying a premium service. Examples are highlighting the experience of their mechanics, or indicating that they offer high quality in other attributes of service and hoping that this reputation will also be inferred concerning their safety performance. The problems in effectively communicating information to passengers probably help explain why most mainstream American airlines have statistically indistinguishable safety records. Airlines would be unwilling to offer a higher level of safety if they believe that passengers would not appreciate that a higher level of safety is being provided and hence would be unwilling to pay higher prices to compensate for the higher costs.

4.3 Consumers Correctly Process Safety Information

Even if passengers were fully informed, they may not make rational choices. The unpleasant consequences of a crash may cause even fully informed passengers to downplay the probability of a crash. Calabresi (1970) explains this “it will not happen to me” behavior as the “Faust” attitude whereby people are myopic when making a choice between a lower price now and an increased probability of death or injury later. Oi (1973) explains the phenomenon as consumers with a very high time preference who in retrospect regret their choices because their retrospective time preference is different. It may well be that cognitive dissonance reinforces the tendency for mainstream airlines to offer similar safety levels because passengers will ignore the lower risk offered by a safer airline, but react negatively to the higher prices that they charge.

4.4 No Complications from Multi-Attribute Competition

In the model described earlier in the chapter, rivalry between airlines occurs in several quality dimensions in addition to safety. Airlines compete on the basis of their schedule, and a whole host of other attributes including in-flight amenities, seat pitch, frequent-flier benefits, ticketing policies, and customer service. It is tough to describe a unique equilibrium when airlines can compete in so many dimensions. Moreover, because passengers can readily compare schedules and amenities, it would seem that airlines would find it more effective to differentiate themselves in these dimensions, and hence blunt price competition, rather than in the rather amorphous safety dimension. This is yet another reason why we may not find much differentiation in terms of safety between mainstream airlines.

4.5 Airlines Know Their Production Functions

The theoretical analysis assumes that firms can definitively decide how much safety they wish to produce, and that a given amount of preventive effort will lead to a given safety performance. There is a growing literature on how safety is produced, with aviation professionals taking a leading role, that suggests that simplistic relationships between maintenance expenditures or staff training and safety outcomes are not sufficient. Safety outcomes depend not only on these direct inputs to safety but also on the layers of “defenses” that companies build into their systems to protect against naturally occurring human and environmental errors (Maurino *et al.*, 1995). It also depends on the “safety culture” that senior management creates throughout the whole organization. The work of Professor James Reason argues that most accidents in high technology systems do not occur as a result of one failure, but are caused by a whole chain of events. Even if one link in the chain can be broken the hazardous circumstance may not result in an accident. Furthermore every “defense” against accidents usually has some, known or unknown, flaw. One could think of this as a hole in a slice of Swiss cheese. For an accident to occur all of the holes in the multiple slices of cheese, that represent the multiple defenses, must be lined up. The implication is that the production of safety is somewhat of a black box. Firms can only make decisions on the inputs to safety, and the number of defenses put in place (i.e., the number of slices of cheese), but the resulting safety level is somewhat unpredictable.

4.6 Regulations do not Truncate the Range of Safety Offerings

This chapter deals with the competitive process and is not a treatise on the many justifications for safety regulation. For our purposes, it is sufficient to note that a minimum safety standard may curtail the range of safety options that airlines could offer to knowledgeable and willing passengers. Depending on how binding the minimum standard is on the distribution of consumer tastes and the commercial decisions of airlines, it is possible that minimum standards may work to compress the range of safety choices offered. In effect we may observe less diversity because regulation is truncating the lowest part of the safety distribution, and some – but not all – passengers in the truncated segment decide to purchase greater safety than they would like at a higher price.

As an aside, there may be an interesting social dynamic at work. In a vertically-differentiated safety market, high-safety choices will be available at premium prices, whereas low-safety choices will be available at discounted prices. Less well-off members of society may only be able to afford to patronize airlines with very poor safety records. Even though these people may make that choice in a fully informed way, society may paternalistically decide that this is not right and that these travelers face “too much” risk. However, if society implements a minimum safety standard that increases the safety offered by low-safety airlines, at least some passengers will be priced out of the market. Implicitly, society is indicating that it would prefer that some consumers not travel rather than face inordinate risks.

5. WHY SOME AIRLINES MAY DEVIATE DOWNWARDS FROM THE PACK

If passengers have imperfect information on safety, it is clear that no rational airline would wish to provide a higher level of safety than mainstream airlines because it would not be able to convince passengers to pay a higher price to compensate for the greater costs that the higher safety level entails. However, on the flip side there would be an incentive to take advantage of passengers by providing less safety. For example, an airline that had previously offered similar safety to its mainstream rivals could make cost savings in its preventive efforts, but would not suffer reduced revenues because it could masquerade as a mainstream-safety airline, and continue to charge the regular price. The incentives to engage in this kind of behavior are even stronger because the costs of prevention are borne in the present, whereas the effects of crashes occur at randomly defined points in the future. Even an airline that becomes very careless may not suffer a visibly increased crash rate for several years. In the interim the airline can earn excess profits, which will cease only when it incurs the costs of crashes and/or when its passengers find out and either shun the airline or demand a lower price.

There is an extensive theoretical and empirical literature concerning such “cheating.” In our discussion we will consider two types of cheating. The first is premeditated, or avaricious, cheating, and the second is involuntary cheating which occurs when a firm does not intend to cheat the customer but does so because of inexperience or a lack of knowledge of its production function. One should note that this is not technically competition on the basis of safety, because the airline that engages in this behavior wants passengers to believe that it is still providing the same level of safety as the other mainstream airlines, and does not cut its price as it wishes to earn a price premium over cost.

5.1 Avaricious Cheating

The most common explanation of avaricious cheating is that the airline is close to bankruptcy. The airline reasons that it can save on prevention costs now and declare bankruptcy to protect itself against the cost of crashes later on.⁵ A less callous explanation may be that a financially distressed airline hopes that cost economies can prolong its life until better times come along. Other explanations are that an airline might feel that it needs a short-term financial boost to improve its stock price or make itself attractive to a potential purchaser, or to prove to stockholders that a recent merger had led to the promised cost savings.

There has been a small but influential literature investigating whether there is an empirical link between financial condition and accident experience.⁶ An early paper by Golbe (1986) was updated and expanded by Rose (1990). Rose’s work used data for 35 large scheduled airlines in the United States over the period 1957 to 1986. She found a negative relationship that was statistically significant at the 10% level: a larger operating margin implied lower accident rates. A decrease in financial performance from average to one standard deviation below average was estimated to increase the accident rate of the airline by 7.5%. When categorized by

⁵ For theoretical treatments see Bulow and Shoven (1978), Golbe (1981), Klein and Leffler (1981), and Shapiro (1982).

⁶ There is always an element of “chicken and egg” with the empirical literature, in that it is not always clear whether the poor financial conditions lead to a larger number of crashes, or vice versa, or some combination of the two.

size of firm, it would appear that the profitability-safety relationship only held for middle-sized and small airlines. There was no statistical relationship for large airlines.

Rose's work was updated by Raghavan and Rhoades (2005) using data on 12 major airlines and 18 regional airlines in the post-deregulation period from 1980 to 2002. Their results were remarkably similar to Rose's. Overall, there was a negative relationship between profitability and safety which was significant at the 5% level. When the data set was divided into major airlines and regional airlines, the sign of the relationship still held for both groups, but it was statistically significant at the 10% level for the smaller regional airlines, and statistically insignificant for the major airlines.

Dionne et al. (1997) conducted a study of 120 Canadian airlines of various sizes using pre-deregulation quarterly data from 1976 to 1987. The definition of accidents was broader than that used by Rose. They, like Rose, found that there was not a statistically significant relationship between operating margin and safety for large airlines. However, for smaller airlines there was a strong *positive* relationship: a larger operating margin implied higher accident rates! The authors then explored alternative measures of financial health, and found more intuitive results. Among the smaller airlines, higher maintenance expenditures were found to reduce accident rates in a statistically significant way. However, this relationship was not found for larger airlines. The use of data on debt to equity ratios provided additional insights. Among the smaller airlines a higher debt to equity ratio (when equity was positive) resulted in greater safety. In addition, airlines with large debts and negative equity (when measured with a lag) were found to have worse safety than those with positive equity.

5.2. Involuntary Cheating

The fact that the production function for safety is ill-defined means that there is the possibility that some incumbent airlines may involuntarily deviate from the safety level offered by other airlines. Nance (1986) argued that the pressures for airlines to trim costs in the period after deregulation in the United States in 1978 led to decisions that could have led to safety reductions. Nance argues that airline vice presidents of maintenance or operations would have a hard time resisting requests for cost reductions because the link between a particular cut and an increase in risk is tough to quantify. In James Reason's terminology, what is the safety consequence of saving money by removing one of the layers of Swiss cheese?

A second group that may involuntarily offer lower safety is new entrants. While these entrants may aspire to provide similar safety to mainstream incumbent airlines, entrants may undertake too little prevention in the present and regret it when crashes and adverse customer reaction occur in the years ahead. While the motivation for some of this behavior might be avaricious, it is more likely to be attributed to inexperience. The complexity of the safety production function only makes this problem worse. This is a very real concern given that there has been considerable new entry since economic deregulation. Investigations show that the new jet airline entrants of the early 1980s in the United States were not noticeably worse than established airlines (Kanafani and Keeler, 1989), but that was not true of the cohort of entrants in the early 1990s (Savage, 1999).

Of course, passengers may suspect that new entrants might provide a lower level of safety than established airlines. Shapiro (1983) presents a model where all new entrant firms are regarded by consumers as providing low quality in their first period of operation. Consequently, all entrants must initially price in a way that is consistent with the prices charged by low quality firms. If an entrant is truly providing high quality then consumers will recognize this after a period of time. As soon as the firm gains a reputation for high quality it can then charge a price consistent with high quality. Of course, the price of high quality will have to contain a mark up over costs because the firm has to recoup, over time, its investment in pricing below costs in its initial period of operation.

6. WHERE SAFETY DIFFERENTIATION DOES OCCUR

The main thrust of this chapter is to provide a theoretical underpinning to explain why most mainstream airlines offer similar safety, and why rivalry on the basis of safety is largely absent. However, one should not assume that it is totally absent. There are two examples that come to mind that feature rivalry between airlines that includes safety differences which are readily apparent to potential passengers.

The first is inter-continental service. Using data from 2000 to 2007, Barnett (2010) states in his abstract that:

“The safest nations are the traditional first-world countries (e.g., Canada, Japan), with a death risk per flight of about 1 in 14 million. Next safest are those developing-world nations that have either have recently attained first-world status (e.g., Singapore, South Korea) or are classified by experts as newly industrialized (e.g., Brazil, China). Their aggregate death risk per flight was about 1 in 2 million. The least safe nations statistically are remaining developing-world countries, with a death risk per flight of about 1 in 800,000.”

Barnett finds that any differences within the various groups, even those within the developing nations group, were statistically insignificant, but that the differences between these three groupings are highly significant. The reason for the safety differential is clear. In developing countries, risks of all types (from disease, workplace risks, and common accidents) are much higher than in the first world, and it is natural to expect that the risks from flying are similarly higher. In markets where the route networks of airlines from these different groups overlap, safety is clearly a differentiating factor in the rivalry.

The second concerns the introduction of regional jets in the past 15 years that has blurred the market boundary between mainline jet airlines and regional airlines. Until the mid 1990s, certain markets were served almost exclusively by turbo-prop aircraft operated by regional or commuter airlines, and other markets were the exclusive preserve of traditional large jet service. Now this is not the case. A couple of parochial examples can illustrate this point. Delta Air Lines recently entered the market between Chicago O’Hare and New York LaGuardia, a market long dominated by United Air Lines and American Airlines. It did so using a regional affiliate, Shuttle America, using Embraer 175 regional jets. United and American provide service with their own staff and equipment using (as of January 2010) primarily Airbus A320-family and McDonnell Douglas MD80 jets respectively. In the market between Chicago O’Hare and

Washington Reagan National, United and American are longtime duopolists. United still primarily operates this service with their own Airbus A320-family and Boeing 757 equipment. American however now splits its flights roughly equally between directly operated flights using Boeing 737-800s, and flights operated by its regional sister company, American Eagle, using Bombardier CRJ700 regional jets. While the public may regard regional jets as inferior in tangible ways such as baggage space and headroom, there is a perception (rightly or wrongly) that smaller aircraft are less safe and that the pilots of regional airlines are less experienced than their large-jet counterparts and work longer hours.⁷

Both of these types of markets provide the opportunity for interesting research studies. Studies could investigate a number of questions. Do the passengers on these routes take into account any safety differences in their airline choice decisions? Does the operator of the (actual or perceived) lower safety option have to offer a lower fare? What is the consequent effect on market share?

7. CONCLUDING REMARKS

Aviation safety is a very emotive subject. The media disproportionately covers aviation crashes relative to other risks in society. In part this is because aviation crashes, unlike most highway crashes, are multiple fatalities events. In part it is explained by psychometric studies that have shown that the uncontrollability of the situation (from the perspective of the passenger) when something untoward occurs leads to a feeling of “dread” and a greater social intolerance of safety lapses.

One would imagine that airlines might cater to these concerns by competing strongly with each other by touting their safety credentials. However, in practice, mainstream airlines seem to offer statistically indistinguishable safety, and do not overly discuss safety in their advertising. Microeconomic theory argues that that is not a profit-maximizing strategy. In general firms should try to differentiate their products as much as possible so as to lessen direct price competition and allow for the possibility of earning super-normal profits. This chapter lays out the standard oligopoly models that support maximal differentiation.

Of course, such models have a variety of underlying assumptions. The chapter discusses each of these assumptions and whether they hold in practice. Clearly airlines would only offer differential safety levels if some passengers preferred high levels of safety whereas others would be satisfied with a slightly lower level of safety that is supplied at a lower price. If all passengers had roughly similar tastes then we would optimal expect to see minimal differentiation. While I personally do think that such a variability of tastes does exist, I cannot point to any empirical studies that provide any statistical support to confirm or refute this.

⁷ The latter was the subject of a National Transportation Safety Board investigation of the crash of Colgan Air flight 3407 near Buffalo, New York on February 12, 2009. The aircraft involved in this accident was a turbo-prop aircraft, operated by a regional affiliate of Continental Airlines. While Colgan Air only operates turbo-prop aircraft, it is part of a larger undertaking that also operates regional jets.

Perhaps the classic market failure is that passengers are not well informed about safety offerings, and internal cognitive processes may further hinder any rational decision making. In these circumstances airlines would not have any incentive to provide safety levels greater than those offered by rival airlines because passengers would not fully incorporate the greater safety levels into their decision making and would be unwilling to pay a higher fare to compensate for the greater safety investment. It is perhaps not surprising that airlines prefer to differentiate their products in more tangible ways such as schedule and frequent-flier privileges rather than compete on the basis of safety.

In some classic economic models failures in information flows can lead to all firms offering the lowest possible levels of quality because no firm has any incentive to invest in quality because they are not rewarded for it. This does not appear to be the case for commercial aviation, where the general level of safety is extremely high. The implication is that while passengers may not be able to differentiate between mainstream airlines, they can recognize a “notorious” airline and act accordingly. The concept of notoriety would appear to present a substantial opportunity for empirical research. Are there examples of airlines that have obtained a notorious reputation for poor safety? What was the mechanism by which this reputation was acquired? Does there need to be a critical number of incidents in a given period before a “tipping point” occurs and an airline obtains a notorious reputation? Is the occurrence of crashes the most important element in determining a reputation, or are there other types of information that might become available that are more damaging?

Finally, while it is generally true that most airlines offer similar safety to their peers in the same geographic region and market segment, there are some markets in which airlines with real or perceived safety differences are pitted against each other. One example is on routes between developed and developing world countries. Another is on routes where regional jet service competes with mainline jet service. These markets provide empirical researchers with the opportunity to investigate how passengers choose between the rival airlines and the consequences for pricing and market share.

In summary, there is a considerable agenda that empirical researchers may wish to tackle.

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Figure 1. Safety costs for a representative flight on a given airline

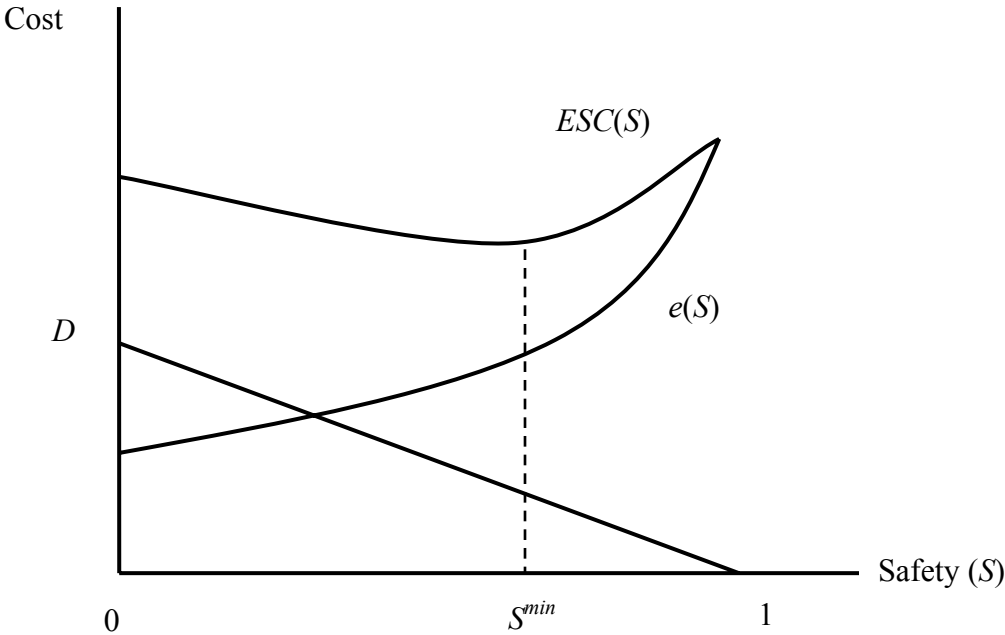


Figure 2. Consumer choice between not traveling by air, and traveling with high or low safety airlines on route j

