

Assessing the Impact of Technological Advancements on the Consumer Experience in Commercial Aviation

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ABSTRACT

Technology has played a major role in changing the passenger experience in commercial aviation. Various laws and regulations in the aviation sector once prevented airlines from setting their own fares, but the eventual deregulation of this sector allowed airlines to create new business models and increase their profitability. This development led to greater competition between airlines and two main models developed: legacy and low-cost. A major trend since deregulation has been the decreased seat pitch in airplanes in order for airlines to maximize their profits. Utilizing classes such as first, business, and economy has allowed companies to negotiate seat pitch with a given price difference per option. The amenities that are available in the air have changed as a result of technological advancements as well. There has been a dramatic impact on inflight entertainment as a result of the better television technology and the development of touch screens. However, travelers believe that the quality of inflight meals has progressively declined. In addition, the impact of artificial intelligence has been massive for airlines, making certain processes more convenient for both the company and passenger. Although most individuals presume that airline companies receive a large profit per passenger, this is not the case since the cost for an average ticket in the commercial aviation industry has increased minimally compared to other industries. This paper analyzes the effects of such factors on the commercial aviation industry and whether the consumer experience has been positively or negatively impacted by them.

Introduction

Since the invention of the airplane in the early twentieth century, the role it has played in society has dramatically changed. Originally, its main purpose was to deliver mail, with various safety risks involved in the process and a great degree of unpredictability in the early days of flight (Cohen). Later, during the First and Second World Wars, the mobilization during the time period allowed planes to have a vital role in aerial fighting, expanding their influence around the world (Sawford and Alston). When commercial aviation began, flying was a habit of the elite, with high ticket prices and few direct flight routes available. As the jet age started in the early 1960s, however, flying became more widely available to citizens in various classes of society (“The Jet Age”). Throughout the history of commercial aviation, the signature characteristic of the airline industry has been the advancement of technological capabilities. In comparison to the past, today’s airlines use fuel-efficient aircraft, varying seat pitch (distance from one seat to the same point on the next seat ahead/behind it), and artificial intelligence in addition to various other capabilities. Airlines constantly change their business models to best meet the demands of society while also simultaneously increasing their profit. Overall, the advancement of technology in the commercial aviation industry has impacted the consumer experience in both positive and negative ways but has generally decreased passenger comfort.

Laws and Regulations in the Aviation Sector

In 1978, Congress passed the Airline Deregulation Act which allowed airlines to set their own fares and routes. Not only did this law change the commercial aviation industry, but it also dramatically affected the passenger experience (“Airline Deregulation”). Hence, airlines could decide where they wanted to fly to and charge their own ticket prices. Originally, this act was met with skepticism because it began the process of abolishing the Civil Aeronautics Board (which previously set all the fares and routes for airlines). However, soon after the law was passed, many new airlines formed, and the great degree of competition rapidly drove ticket prices down (“Airline Deregulation”). As passengers used air travel at record levels, airlines began using hubs as bases to center their operations while maximizing efficiency and profits. The ensuing competition meant that airlines started merging to gain a larger share of the market (Chakrabarty and Kutlu 3421-3422). Through Title 14 of the Federal Code of Regulations, Congress has further established rules for the commercial aviation sector while also delegating rulemaking power to the Federal Aviation Administration (FAA) through the Department of Transportation (Chakrabarty and Kutlu 3421-3422). Examples of topics that the code covers include airspace, air traffic and operating rules, navigational facilities, and airports (Chakrabarty and Kutlu 3421-3422).

Analysis of Seat Pitch and Potential Regulations

The advancement of technology in the aviation industry has had a major impact on seat pitch in commercial airplanes. According to a report from the University Aviation Association, “As airlines work to evaluate and develop their pricing models, a recent trend of the last three decades has been the decrease in seat pitch. During the 1970s, seat pitch ranged from 31 to 35 inches while today it has been reduced to 28 inches on some of America’s low-cost carriers” (Winter 2). The fundamental reason for this change can be attributed to the Airline Deregulation Act of 1978. Since airlines had the ability to set their own rules and regulations, they also wanted to maximize their profits by fitting more seats on planes. These changes come with a major tradeoff since passenger comfort is decreased at the expense of a greater profit per passenger for the company. Although low-cost carriers engage in this practice more often than other airlines, legacy carriers, such as Delta and United, have also considered reducing their seat pitch to 28 inches (see Chart 1). This reduction also raises various safety concerns for travelers. The addition of more seats makes it difficult to meet “the regulatory requirement that commercial aircraft be completely evacuated in less than 90 seconds in an emergency” (Winter 3). Furthermore, passenger health is put in jeopardy since some may develop deep vein thrombosis as a result of long travel without frequent movement (Winter 3).

A study by Scott Winter of Embry-Riddle Aeronautical University focuses on potential governmental need to regulate seat pitch (4). The premise was to determine passenger perceptions of federal government regulations in addition to the factors that affected their views (Winter 5). The results showed that 60% of participants agreed or strongly agreed that the federal government should have such regulations with 65% stating the seat pitch should be increased (see Figure 1). Thus, there is a general consensus that travelers believe the pitch in its current form is not comfortable, and necessary changes should be made (Winter 6).

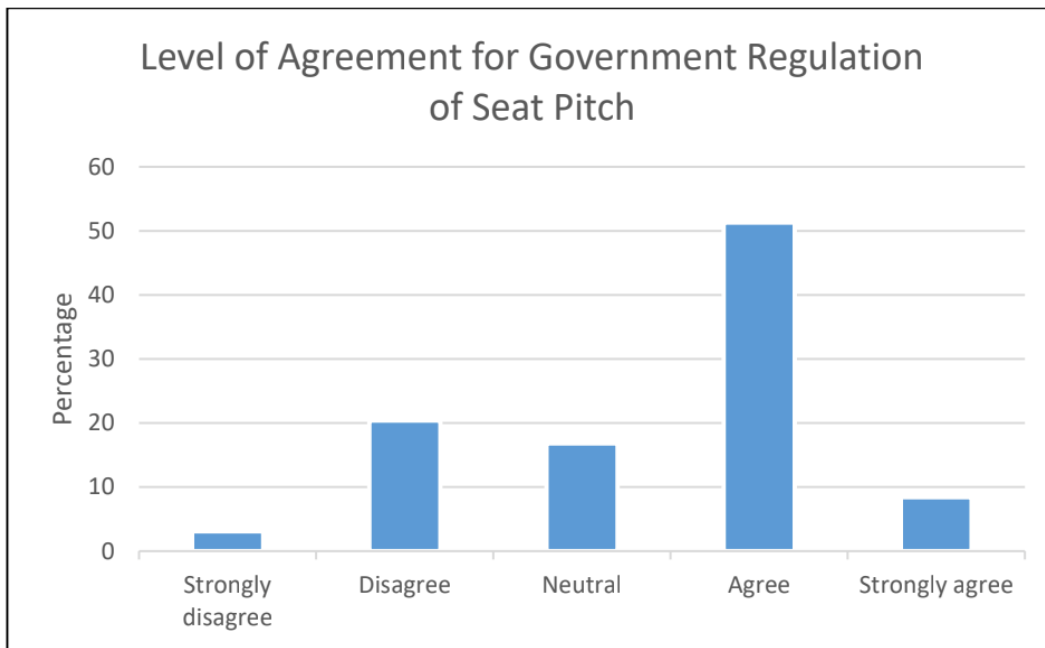
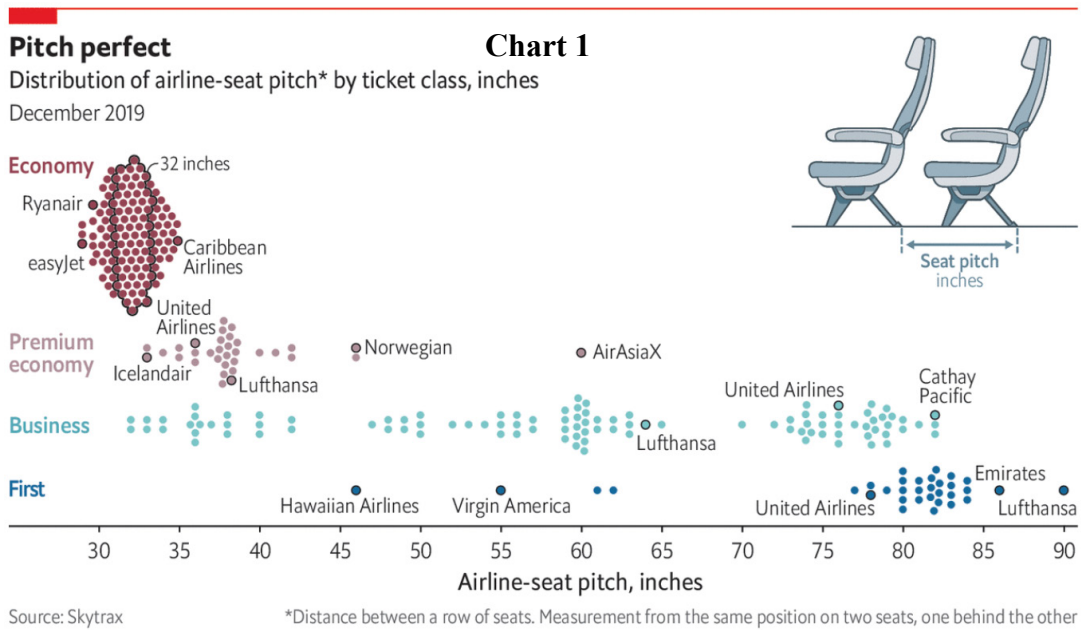


Figure 1: Opinions on Seat Pitch Regulation

Types of Classes in Airlines

In the traditional aviation industry, there are three major classes: first, business, and economy. However, starting in the middle of the 1990s, some airlines started adding a premium economy class to serve as a middle ground between

economy and business (Winter 2). Each class contains differences based on whether the flight is international or domestic. Normally, first or business class fares are much higher, but they do include complimentary alcoholic beverages, meals, larger seat pitch, and sometimes even free Wi-Fi. Since premium economy is newer, different airlines have various offerings for it. This class typically has a few additional inches of legroom compared to economy and a complimentary snack or beverage on a domestic route (Winter 2). Some airlines allow free cancellation and the ability to choose seats free of charge as well. Economy class serves as the most basic of the four and contains minimal seat pitch and complimentary non-alcoholic beverages with snacks usually available for purchase. Most domestic airlines today do not allow free cancellation or seat selection (Winter 2).

Types of Carriers and Business Models

Technological changes have resulted in structural differences in airlines throughout the past forty years. They can be categorized into two separate categories today: legacy carriers and low-cost carriers. Domestic examples of the former include American, United, and Delta while international examples include Lufthansa, KLM, and British Airways. Legacy carriers “offer a high-quality product and superior service level on an extensive route network” while low-cost carriers “operate at extremely low-cost levels with inexpensive fares and service offering reduced to the main purpose transportation” (Coto-Millán et al. 488). Domestic examples of the latter include Southwest, Spirit, and Jet-Blue while international examples are Ryanair, AirAsia, and EasyJet. Originally, the first recognized low-cost carrier in the world was Southwest Airlines. It was founded in 1966, and its operations began in 1971. The advancement of the jet age proved to be a vital component for the future of low-cost carriers. Southwest began by using Boeing 737-200 aircraft for its flights. At that time, however, the federal government still regulated airfares and routes, so the airline’s true success began after the Deregulation Act. It was during that time that a plethora of other low-cost carriers were formed because airlines had the freedom to set their own fares. Throughout the years, greater fuel efficiency for aircraft has allowed airlines, specifically low-cost carriers, to decrease their cost of gas. Today, legacy carriers focus on using their hubs to link both domestic and international passengers to their destinations through primary and secondary airports (Coto-Millán et al. 489). They also have a broader market for travelers since low-cost carriers typically fly domestic or within their respective continents. Hence, these carriers need to use a variety of both long-haul and short-haul aircraft to facilitate their needs. For example, Delta Airlines uses the Airbus A350-900 for intercontinental travel and the Airbus A320-200 for domestic flights within the United States. In contrast, low-cost carriers typically have a fleet of a single type of aircraft to allow for “greater homogeneity, lower maintenance costs, and higher productivity” (Coto-Millán et al. 488). This allows them to carry out a greater number of flights per day by reducing the time that the planes spend on the ground. Southwest Airlines, the largest low-cost carrier in the world, has the world’s biggest fleet of Boeing 737s which increases the efficiency of the company. These airlines use vertical integration as their business model to increase their profitability by charging a variety of fees. If the weight and size of baggage does not meet the carrier’s requirements, a large fee is charged for the excess baggage (Coto-Millán et al. 489). Originally, the low-cost carrier business model was based on the concept of vertical differentiation which allowed each airline to adopt certain qualities to make itself more appealing to consumers. The focus was to have lower prices and short flights not exceeding two hours in length (Coto-Millán et al. 489). However, as competition between the airlines has grown, the model had shifted towards horizontal differentiation in which the carriers offer flights at extremely similar price levels, so it is the quality of the travel experience that influences whether an individual will decide to travel with one airline over another (Coto-Millán et al. 489). For instance, if Frontier and Spirit Airlines both had the same price for a customer traveling from Philadelphia to Chicago, then customers would resort to other means to make their choice; they might consider the delay rate of each airline, customer reviews, or a combination of such factors.

Amenities in the Air

Inflight Entertainment

Amenities in the air vary between the multitude of airlines in the travel industry. Three of the most important aspects companies try to balance are inflight entertainment, internet, and meals. The influence of technology has had a dramatic impact on how these services have changed throughout the years. The first use of inflight entertainment was in the earliest days of flying when Aeromarine Airways projected the film *Howdy Chicago* in 1921 (Pande). However, such occurrences were sporadic in the early days of aviation. The first airline with regular inflight entertainment was Trans-World Airlines (TWA) in 1961. By using the projection technologies available at the time, the company could show any movie that it wanted while attracting passengers in the process (Pande). The 1980s marked the first time that individual passengers had access to seatback entertainment. In 1988, Northwest Airlines installed in-seat LCD monitors on its Boeing 747 aircraft. Hence, travelers were able to access on-demand entertainment for long-distance flights, making the experience more enjoyable and convenient as well (Singh). This same standard is prevalent in the majority of airlines today. Carriers use LED monitors with a plethora of movies, programs, songs, and games available to individuals (Singh). On international routes, first and business class normally contain monitors the size of small televisions while those in economy class are similar to tablets. Until the past few years, most domestic flight operators did not provide entertainment, but recently, some have included seat-back monitors. Others, such as Alaska Airlines, have started offering free entertainment if passengers bring their own tablets or devices. With the advancement of Wi-Fi technology within the past twenty years, airlines started offering inflight internet, although there is usually a fee that passengers have to pay to use it (Pande). Still, these advancements have had a significant positive impact by making air travel more convenient and enjoyable.

Inflight Meals

Inflight meals have dramatically changed from the Golden Age of air travel (in the 1950s-1970s) to the modern day. In those days, passengers were treated to more than just a three-course meal. An international or domestic economy class meal on Pan American Airlines, a leader in food service at the time, consisted of “a tropical-fruit cocktail, followed by cream of tomato soup, a half-broiled chicken with wine sauce, wax beans and Delmonico potatoes” with “Boston cream pie and Blue Mountain coffee” for dessert (Compton). Travelers were even able to pick from an assortment of wine and spirits (Compton). According to Matthew Burchette, senior curator of the Museum of Flight in Seattle, airlines at the time even used tablecloths and real silverware, something that would be unthinkable today. However, this practice changed with the deregulation of the airline industry (Compton). Commercial airline historian Shea Oakley states that “Deregulation was the game-changer because you had all these low-cost carriers come in and start to compete against the higher-class carriers [and airlines] started cutting back. They would still feed you on long-distance flights, transcontinental or international flights, but domestic passengers started getting next to nothing” (Compton). Essentially, the entire landscape had changed because air travel was now a method of “mass transportation” and the model shifted to greater efficiency and speed rather than service at the expense of travelers, having a negative impact on the consumer experience. Economy travelers today are lucky even if they are offered complimentary pretzels or drinks, a large contrast from the courses of meals in the past (Compton). Instead, travelers encounter overpriced boxes of snacks with poor food quality.

The Impact of Artificial Intelligence on Air Travel

Within the last decade, the influence of artificial intelligence (AI) on air travel has changed consumer interactions with airlines. In many airports today, AI technology creates a more convenient experience with kiosks for both the check-in process and international arrivals. These kiosks scan a person’s face with a biometric device and then use sensors to match their unique features (shape of ear, mouth, etc.) with their identity (Snow). After corroborating this

information with the passport and ticket numbers, they will automatically print the boarding passes and luggage tags, meaning greater ease of travel for the passenger instead of waiting in long lines at the physical check-in counter. The facial-recognition technology has worked in the coronavirus pandemic too, identifying individuals with masked faces. Even at the boarding gate, some gates have a scan-and-board system in which passengers would scan their boarding passes at an automated gate that would open to allow them to use the jet bridge (Snow). The effects of the COVID-19 pandemic brought unprecedented levels of sanitization to airports to account for the health and safety of passengers. Airports started using ultraviolet C (UV-C) technology to combat the effects of the coronavirus. Since this wavelength damages the DNA and RNA of a virus, it causes it to stop replicating and eventually die (Snow). Working with Carnegie Robotics, Pittsburgh International Airport was the first to test out this technology by installing it onto their cleaning robots (Snow). Although UV-C has been used throughout the pandemic, more traditional cleaning robots are also plentiful in modern airports. In Cincinnati/Northern Kentucky International Airport, the Neo, a thousand-pound, \$50,000 robot, scrubs the floor of the terminal (Snow). Designed by the Canadian technology company AvidBots, the Neo uses 3D and laser technology to navigate through the terminal, bypassing stores, kiosks, and passengers (Snow).

Changes in Airfare and Costs

Since the passage of the Airline Deregulation Act, airline companies have been competing at levels that have greatly exceeded the expectations at the time of the law. Deregulation has provided the opportunity for the liberalization of airlines by removing limitations on pricing and routes (Xiaowen et al. 25). With airlines trying to gain a competitive advantage, liberalization has had a monumental role in the growth of the air transportation industry (Xiaowen et al. 26). Although the act was signed at the end of the 1970s, its impact has continued for over four decades. According to the International Civil Aviation Organization, over a ten-year period, the total number of annual passengers grew by 46%, increasing from 1.457 billion in 2000 to 2.128 billion in 2010 (Xiaowen et al. 26). At the same time, the price that travelers have to pay relative to inflation has decreased, making it more affordable to travel. This creates a situation in which lower prices have to be compromised by greater passenger traffic. Although many believe that commercial aviation ticket prices have increased dramatically in the past decades, that is not the case relative to inflation (Xiaowen et al. 27). While the urban consumer price index (CPI) depicts an average growth of 3.1 times for the price of goods and services between 1978 and 2006, domestic and international air travel averaged a price per mile of 1.55 times what it was in 1978, half the increase of the CPI (see Table 1). The tuition for public and private universities increased an average of 8 times what it was in 1978, almost 5 times the increase in air travel. Furthermore, the price of an average movie ticket even increased, from \$2.34 to \$6.55, almost twofold compared to the commercial aviation industry (see Table 1) (Xiaowen et al. 28). Hence, a relatively small increase in the price compared to other industries, such as the housing and medical markets, is a positive impact of the competition between airlines. However, in order to account for these fares, airlines charge additional fees to try to increase their profit per passenger (Chakrabarty and Kutlu 3422-3423). In the modern-day, baggage, seat selection, change of reservation, and cancellation fees all create both confusion and tension for passengers (Huang and Chang 161-163). This serves as the negative side of competition for the average consumer.

Table 1. Price Changes of Air Travel versus Other Goods and Services

Item-U.S. Good or Service	Unit	1978	1990	2006	Growth
College tuition: public	Year	\$688	\$1,908	\$5,836	8.5x
College tuition: private	Year	\$2,958	\$9,340	\$22,218	7.5x
Prescription drugs	Index	61.6	181.7	363.9	5.9x
New single-family home	Home	\$55,700	\$122,900	\$246,500	4.4x
New vehicle	Vehicle	\$6,470	\$15,900	\$28,450	4.4x
Unleaded gasoline	Gallon	\$0.67	\$1.16	\$2.59	3.9x
CPI (Urban-all items)	CPI-U	65.2	130.6	201.6	3.1x
Movie ticket	Ticket	\$2.34	\$4.22	\$6.55	2.8x
First-class postage	Stamp	\$0.15	\$0.25	\$0.39	2.6x
Whole milk	Index	81.0	124.4	181.6	2.2x
Grade-A large eggs	Dozen	\$0.82	\$1.01	\$1.31	1.6x
Air travel: international	Mile	7.49¢	10.83¢	11.85¢	1.6x
Air travel: domestic	Mile	8.49¢	13.43¢	13.00¢	1.5x
Television	Index	101.8	74.6	22.3	0.2x

Seat Pitch Changes and Profitability

As previously mentioned, seat pitch is another way that airlines compete since carriers decrease it to add more seats to the plane for optimal revenue. Air Canada has taken this concept to a new level by also decreasing the seat width. After eliminating first class from its Boeing 777 aircraft, “The new plane will feature three cabins - business, economy, and premium economy - and will pack in 109 more paying customers than existing 777s, boosting the total number of passengers per plane to 458 from 349. As if it needed saying, most of the extra bodies will be squeezed into the economy-class cabin. Each seat is about 43 cm across instead of the usual 46 cm, allowing them to be laid out in rows that are ten across instead of the standard nine” (Sorensen 48-49). By using revenue management (RM), a common practice that airlines partake in today is overbooking (Huang and Chang 162). In order to do this, airlines have to evaluate the expected bookings, cancellations, and those who do not show up (Huang and Chang 162). Developed by Tak Lee and Marvin Hersh in 1993, the DP model accounts for such factors using a specific mathematical algorithm (see Equation 1). Since overbooking is based on modeling, it does not always account for what happens in reality as sometimes too many individuals arrive at the gate and are assigned the same seat (Huang and Chang 163). Instead of valuing customer experience, this style of revenue management puts profit before the satisfaction of travelers.

$$f_s^n = \begin{cases} P_{0,s}^n f_s^{n-1} + P_1^n (F_1 + f_{s-1}^{n-1}) \\ \quad + \sum_{i=2}^k P_i^n G_{\max}(F_i, \delta_s^{n-1}) \\ \quad \text{for } n > 0, \quad s > 0 \\ 0 \quad \text{otherwise} \end{cases} \quad (1)$$

where

$$P_0^n = 1 - \sum_i^k P_i^n$$

$$G_{\max}(F_i, \delta_s^{n-1}) = \begin{cases} F_i + f_{s-1}^{n-1} & \text{if } F_i \geq \delta_s^{n-1} \\ f_s^{n-1} & \text{else} \end{cases} \quad (2)$$

$$\delta_s^n = f_s^n - f_{s-1}^n \quad (3)$$

Equation 1

i : indices of fare classes ($i = 1 \dots k$, assuming $i = 1$ is the highest-fare class and $i = k$ is the lowest)

n : indices of decision periods ($n = 0 \dots N$, assuming $n = 0$ is the period of take-off)

s : available (unsold) seats ($s = 1 \dots C$, assuming that C is the flight capacity)

F_i : rate of fare class i

P_i^n : probability of booking request for fare class i at decision period n

f_s^n : expected total revenue given s available seats at decision period n

Conclusion

When considering the impact of technological advancements on the consumer experience as a whole, it is evident that they have provided both positive and negative aspects for travelers. The Airline Deregulation Act of 1978 has had the largest impact on the evolution of the airline industry by accelerating the development of airlines to compete for airspace and a larger section of the market. The development of low-cost carriers in that time period continues to put pressure on the traditional, legacy carriers to this day, limiting the degree to which each carrier can raise its prices. Airlines have clearly increased their entertainment offerings by expanding access to seatback entertainment and on-demand streaming for their customers, but that has been negotiated with the decline in food quality and the overpriced snacks sold on domestic flights. The ease of the travel experience in terms of speed has been improved as well through the development of online check-in and facial recognition of airport kiosks, but it comes at the expense of baggage, seat selection, and a variety of other fees. The factor that receives the most attention, however, is seat pitch, which has been studied extensively for the average traveler in economy class. The decrease of this pitch over the past forty years has significantly reduced passenger comfort and the travel experience due to the increase in competition. Although it remains to be seen what will happen in the future, the data trends indicate that the pitch and width of seats will continue to decrease. The degree to which airlines are willing to risk passenger comfort at the expense of profits will undoubtedly shape the future of the market.

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