Fundamentals and Structure of Aviation Systems

Andreas Wittmer and Thomas Bieger

Contents

A. Wittmer et al. (eds.), *Aviation Systems*, Classroom Companion: Business, https://doi.org/10.1007/978-3-030-79549-8_2

Summary

- The history of aviation beginning with the first drawings and flying items goes back to the fifteenth century.
- The aviation industry has grown to a remarkable size over the last century and is one of the important industries of economic growth today.
- The aviation industry is structured along the aviation value chain.
- Air transport is characterised by high fixed costs, low profit margins in a growing market and by its dependence on external factors.
- The stakeholders of aviation profit from the economies and drivers of aviation.
- The aviation system model includes different environments, such as the economic, ecological, social, technological and political environments, which are impacted by and influence the aviation market.

The history of aviation and the dream of flight dates back many centuries and includes pioneers such as Leonardo da Vinci, Otto Lilienthal and the Wright Brothers, who contributed to this quest. The last century brought along a remarkable growth of the aviation sector and resulted in considerable economic importance of the industry. The aviation industry can be projected along the aviation value chain and comes with its own special characteristics. Whilst aviation creates a high value for customers and other stakeholders, the profit margins are typically low due to high fixed costs and its dependence on external factors. The benefits of aviation to the economy as well as other drivers create positive effects for many stakeholders who are directly or indirectly involved in the system. The aviation system is surrounded by different environments: the economic, ecological, social, technological and political environments. Each environment exerts influence on the aviation system and is simultaneously affected by it.

2.1 Introduction

The aviation industry is characterised by constant change. The ongoing liberalisation of markets, technological progress, environmental challenges and the establishment of new business models including intermodal transport options, but also the increasing awareness of climate change and CO_2 are just a few examples that illustrate the dynamic development of air transportation within the last years. The fact that there are various fields of development indicates that the industry development is not only influenced by the industry actors themselves, but also by its institutional surroundings and the different spheres of its environment, economic, social/political and natural environments. In turn, the development of the industry shapes its actors and competition structures. It also has significant impact on its environment as an economic and social factor, but also through its effects on the natural environment, of which CO_2 is a significant issue today. The interdependencies among the different stakeholders in aviation and the continuous industry development thereby constantly raise new questions for both theory and practice.

Due to the industry's importance as a provider of employment and as an enabler for social exchange and international trade, its ongoing development is of high relevance for the society and economy. Air transport is a driver of international trade, globalisation and global economic prosperity. The aviation industry as a whole is worth over USD 1300 billion whereof USD 1000 billion are direct, indirect and induced effects, employs about 65.5 million people whereof 10.2 million people work directly in the aviation industry (ATAG, 2020), and transports and services about 4.5 billion passengers a year (ATAG, 2020). In 2019, 915 million tonnes of freight was transported by air (ATAG, 2020), being responsible for global just in-time production chains. About 35 percent of the global trade (by value) reaches their markets by air, whilst covering less than 1% in volume (Shepherd, Shingal, & Raj, 2016), making air transportation an important part of international trade. Today, air transportation is an essential component of leisure and business-related travelling, and thus of human connectivity and worldwide economic integration (Sterzenbach & Conrady, 2003). Aviation is also at the heart of travel and tourism, the world's largest industry, supporting 36.7 tourism jobs, to equates to one in eight tourism jobs (ATAG, 2020).

The aviation industry today also is in the focus because of its environmental impacts. Most important factors to be mentioned are CO_2 emission, although there are other gases and compounds with an impact on the environment. The aviation industry in the last decades made significant progress regarding noise reduction and fuel efficiency of engines. Whereas in the 1960s around 12 litres per 100 km per seat were consumed today only around 2–3 litres are used per 100 km per seat (loaded seats are assumed) (Pompl, 2007). But the tremendous growth of the demand for air transport and the growth of the industry overcompensated these gains. Today around 8% (Planète Energies, 2019) of worldwide consumption of fossil fuel and 2–3% of CO_2 emission (International Energy Agency, 2020) can be attributed directly to flying. The use of alternative sources of energy is limited because fuel still is the densest form of energy (Joule per Kg) (not taking into account fuel for nuclear power). The aviation industry, therefore, must optimise the maximum in the framework of the existing technologies and at the same time venture new frontiers like maybe in a first-stage renewable fuel and later on new flying technologies based on new forms of engines. Environmental issues, therefore, on the forefront of aviation management and long-term competitive advantages may arise from this field. The importance of sustainable management will even grow as financial markets define sustainability as a key investment quality (Eccles & Klimenko, 2019).

From a theoretical point of view, there are two aspects that justify the selection of the aviation industry as a research subject. First, the industry's complexity and its dynamism constantly raise new questions and open up fields that have hardly been investigated by academia. It is a typical VUCA (volatile, uncertain, complex, ambiguous) industry (Mack et al., 2015). Secondly, theoretical findings about the aviation industry may be applied beyond this context to other industries. In regard to various developments (e.g. dynamic pricing, global network development and alliance formation, customer value applications and today even sustainability management etc.), aviation serves as an industry precursor, making the research results valuable for broader application, e.g. in other industries.

2.2 Historical Development of Air Transport

This section provides an overview about the history and development of the aviation industry. It is split into different stages of development:

- 1783–1917 Technical development
- 1918–1928 Pioneer stage
- 1929–1944 Political development, bilateral flights and technical stage
- 1945–1970 Internationalisation, development of quality and cost
- 1971–1990 Networks, alliances and low-cost operations
- 1991–2005 Deregulation and customer value
- 2006–2018 Consolidation, new materials and technologies
- 2019 + Environment concerns and new technologies (fuels)

Aviation history deals with the development of mechanical flight. It ranges from earliest attempts at flying kite-powered devices or gliders to person-controlled and -powered flying.

Humanity's desire to fly possibly first found expression in China, where flights by humans tied to kites (as a punishment) are recorded from the sixth century AD (Anno Domini, After Christ). Subsequently, the first hang-glider was demonstrated by Abbas Ibn Firnas in Andalusia in the ninth century AD. Leonardo da Vinci's (fifteenth century) dream of flying found expression in several designs, but he did not attempt to demonstrate that flying was possible. It was in post-industrial Europe, from the late-eighteenth century onwards, that serious flight attempts were made, with progression from lighter-than-air flight (hot-air balloons, 1783), to unpowered heavier-than-air flight by Otto Lilienthal, 1891, and finally, to powered sustained flight by the Wright Brothers 1903.

The dream of flying is fuelled by the observation of birds and is illustrated in myths across the world (e.g. Daedalus and Icarus in Greek mythology, or the Pushpaka Vimana of the Ramayana). The first attempts to fly often drew on the idea of imitating birds, like Daedalus did building his wings out of feathers and wax. Attempts to build wings of various materials and jump off high towers continued well into the seventeenth century.

Systematic attempts began with hot air balloons and kites in China. The Kongming lantern (proto hot air balloon) was known in China from ancient times. Its invention is usually attributed to General Zhuge Liang (180–234 AD, honorific title Kongming), who is said to have used them to scare the enemy troops. The balloon was made of a large paper bag, below which an oil lamp was installed. Due to the lamp heating the air below the bag, the bag floated in the air. According to

Joseph Needham,[1] hot-air balloons in China were known since the third century BC (Before Christ). During the Yuan dynasty (thirteenth century), under rulers like Kublai Khan, it became popular to use rectangular lamps at festivals where they would attract huge crowds. In 559 AD, human flight using a kite was documented during a dispute over succession in the Northern Wei kingdom. In 852 AD, first parachutes and gliders were flown in Spain and England. Some five centuries later, Leonardo da Vinci came up with a hang-glider design in which the inner parts of the wings are fixed, and some control surfaces are provided towards the tips. While his drawings still exist and are deemed flight worthy in principle, Leonardo da Vinci himself never flew such a hang-glider.

The first published paper on aviation was the "Sketch of a Machine for Flying in the Air" by Emanuel Swedenborg published in his periodical 1716. This flying machine consisted of a light frame covered with strong canvas and equipped with two large oars or wings moving on a horizontal axis, arranged in such a way that the upstroke met with no resistance, while the down stroke provided lifting power. Swedenborg knew that the machine would not fly, but he thought of it as a good starting point and was confident that the problem of flying would be solved. He said, "It seems easier to talk of such a machine than to put it into actuality, for it requires greater force and less weight than exists in a human body. The science of mechanics might perhaps suggest a means, namely, a strong spiral spring. If these advantages and requisites are observed, perhaps in time to come someone might know how better to utilize our sketch and cause some addition to be made so as to accomplish that which we can only suggest. Yet there are sufficient proofs and examples from nature that such flights can take place without danger, although when the first trials are made you may have to pay for the experience, and not mind an arm or leg." Swedenborg would prove prescient in his observation that powering the aircraft through the air was the crux of flying.

2.2.1 Technical Development 1783–1917

The first generally acknowledged human flight took place in Paris in 1783. Jean-François Pilâtre de Rozier and François Laurent d'Arlandes went 5 miles (8 km) in a hot air balloon invented by the Montgolfier brothers. The balloon was powered by a wood fire. Ballooning became a major "rage" in Europe in the late-eighteenth century, providing the first detailed understanding of the relationship between altitude and the atmosphere. Work on developing a steerable (or dirigible) balloon (today called an airship) continued sporadically throughout the 1800s. The first powered, controlled, sustained lighter-than-air flight is commonly believed to have

1 Joseph Terence Montgomery Needham (9 December 1900–24 March 1995) was a British biochemist, best known for his work on the history of Chinese science. He was elected a fellow of both the Royal Society and the British Academy. In China, he is known mainly by his Chinese name Li Yuese.

taken place in 1852 when Henri Giffard flew 15 miles (24 km) with a steam engine driven craft in France ("History of aviation,", n.d.).

During the last years of the eighteenth century, Sir George Cayley started the first rigorous study about the physics of flight. In 1799, he exhibited a plan for a glider which, except for its form, was, from today's perspective, already completely modern. It showed a separate tail for control and provided for the pilot to be suspended below the centre of gravity to ensure stability. Cayley flew it as a model in 1804. Over the next five decades he worked on the problem, inventing most of basic aerodynamics and introducing such terms as "lift" and "drag." He used both internal and external combustion engines, fuelled by gunpowder, but it was left to Alphonse Penaud to make powering models simple, using rubber power. Later, Cayley turned his research to building a full-scale version of his design. First, he flew it unmanned in 1849; in 1853, his coachman made a short flight at Brompton near Scarborough in Yorkshire.

First test flights with gliders began in the middle of the nineteenth century when several pioneers made short flights or jumps. Scientists started to publish more papers about aerodynamics and the subject of flying in general. In the 1880s, first advancements were made in the construction of gliders which led to the first truly practical gliders. Otto Lilienthal was one of the particularly active researchers who flew with and controlled his glider. He produced a series of good gliders, and in 1891, was able to make flights of 25 meters or more routinely. He rigorously documented his work, including photographs, and therefore is one of the best known of the early pioneers. He also promoted the idea of "jumping before you fly," suggesting that researchers should start with gliders and work their way up, instead of simply designing a powered machine on paper and hoping it would work. Lilienthal knew that once an engine was attached to the plane, it would be difficult to further study the laws of aviation. Finding and describing many of those laws was the greatest heritage he made to his successors. By the time of his death in 1896, he had made 2500 flights on a number of different designs of gliders. His death was caused by a gust of wind that broke the wing of his latest design. He fell from a height of roughly 56 ft. (17 m) fracturing his spine. Lilienthal died the next day, his last words being "sacrifices must be made.." Up to his death, Lilienthal had been working on small engines suitable for powering his designs.

Picking up where Lilienthal had left off, Octave Chanute took up aircraft design after an early retirement and funded the development of several gliders. In the summer of 1896, his troop flew several of his designs a number of times at Miller Beach, Indiana, eventually deciding that the best was a biplane design that, from today's point of view, looked surprisingly modern. Like Lilienthal, he documented his work meticulously, using also photographs, and was busy corresponding with like-minded hobbyists around the world.

Chanute was particularly interested in solving the problem of natural stability of the aircraft in flight; birds did this by instinct, but humans would have to do it manually. The most disconcerting problem was longitudinal stability because as the angle of attack of a wing increased, the centre of pressure moved forward and made the angle increase more. Without immediate correction, the craft would pitch up and stall.

On the basis of the research documented by Lilienthal and Chanute, several other researchers worked on better controllable aircrafts with engines. At the same time that non-rigid airships were starting to have some success, rigid airships were also becoming more advanced. Indeed, rigid body dirigibles would be far more capable than fixed-wing aircraft, in terms of pure cargo carrying capacity, for decades. Dirigible design and advancement was brought about by the German count Ferdinand von Zeppelin.

Between 1900 and 1902, the Wright brothers built and tested a series of kite and glider designs before attempting to build a powered design. The gliders worked, but not as well as the Wrights had expected, based on the experiments and writings of their nineteenth-century predecessors. In 1903, the first sustained flight with a powered controlled aircraft took place successfully. Flyer I and II were used for several test flights; a number of crashes happened. When rebuilding the flyer, calling it Flyer III, after a severe crash on 14 July 1905, the Wrights made radical changes to the design. They almost doubled the size of the elevator and rudder and moved them further away from the wings – about twice the distance than before. They also added two fixed vertical vanes (called "blinkers") between the elevators and gave the wings a very slight dihedral. They disconnected the rudder of the rebuilt Flyer III from the wing-warping control and, as in all future aircraft, placed it on a separate control handle. When testing of Flyer III resumed in September, the results were almost immediate. The bucking and veering that had hampered Flyers I and II were gone and the Wrights experienced no more minor crashes, which had happened frequently with the two previous models. The flights with the redesigned Flyer III started to last over 20 minutes. Thus, Flyer III became a practicable as well as dependable aircraft, flying solidly for a consistent duration, bringing back its pilot to the starting point safely, and landing without causing damage to itself. On 5 October 1905, Wilbur flew 24 miles (38.9 km) in about 40 minutes. In 1908, the Wright brothers conducted the first passenger flight in the United States.

Several researchers built and tested powered planes within the following years. On 25 July 1909, Louis Blériot flew the Blériot XI monoplane across the English Channel, winning the *Daily Mail* aviation prize. His flight from Calais to Dover lasted 37 minutes. On 22 October 1909, Raymonde de Laroche became the first woman to pilot and solo a powered heavier-than-air craft. She was also the first woman in the world to receive a pilot's licence. The first seaplane was invented in March 1910 by the French engineer Henri Fabre. Its name was *Le Canard* ("the duck"). The plane took off from the water and flew 800 metres on its first flight on March 28, 1910. His experiments were closely followed by the aircraft pioneers Gabriel and Charles Voisin, who purchased several of the Fabre floats and fitted them to their Canard Voisin airplane. In October 1910, the Canard Voisin became the first seaplane to fly over the River Seine, and in March 1912, the first seaplane to be used militarily from a seaplane carrier, *La Foudre* ("the lightning").

2.2.2 Pioneer Stage 1918–1928

In World War I, planes were used for the first time for military purposes. During that time the military supported the development of planes strongly. These were mostly double decker planes produces in wood and cloth. They were weather dependent and could not fly in wet conditions.

Aircraft evolved from being constructed mostly of wood and canvas to being constructed almost entirely of aluminium. Engine development proceeded apace, with engines developing from in-line water cooled gasoline engines to rotary and radial air-cooled engines, constituting a commensurate increase in propulsive power. All of this development was pushed forward by prizes for distance and speed records. Charles Lindbergh, for instance, took the Orteig Prize of $25,000 for his solo non-stop crossing of the Atlantic in 1927. He was the first person to achieve this, although not the first to carry out a non-stop crossing. Latter was achieved 8 years earlier when Captain John Alcock and Lieutenant Arthur Brown co-piloted a Vickers Vimy non-stop from St. John's, Newfoundland, to Clifden, Ireland, on 14 June 1919, winning the Northcliffe prize worth GBP 10,000 (USD 50,000).

Mail and single-passenger transport became more popular, but it was an adventurous mode of transport, which was dependent on weather. The Warsaw Convention for limitation of liability was reached in 1929.

2.2.3 Political Development 1929–1944

In the 1930s, development of the jet engine began in Germany and England. In England, Frank Whittle patented a design for a jet engine in 1930 and started building an engine towards the end of the decade. In Germany, Hans von Ohain patented his version of a jet engine in 1936 and began developing a similar engine. The two men were unaware of each other's work, and both Germany and Britain had developed jet aircraft by the end of World War II.

World War II saw a drastic increase in the pace of aircraft development and production. All countries involved in the war stepped up the development and production of aircraft and flight-based weapon delivery systems, such as the first long-range bomber. Fighters were critical to the success of the heavy bombers, as they ensured that the number of losses was lower than it would have been without fighter protection. A number of technological advances that were remarkable for its day are the following: The first functional jet plane was the Heinkel He 178 (Germany) flown by Erich Warsitz in 1939. The first cruise missile (V-1), the first ballistic missile (V-2) and the first manned rocket Bachem Ba 349 were also developed by Germany; however, the small number of jet fighters did not have a significant impact. The V-1 was not very effective, as it was slow and vulnerable, and the V-2 could not hit targets precisely enough.

With the emergence of longer flights and the possibility to fly over other countries, some international regulation was needed. The central convention in the field of international air law is the agreement concerning international civil aviation reached on 7 December 1944 (Chicago Convention – CHI) (SR 0.748). Due to its universal character the Chicago Convention is the fundamental policy for the post-war development of international civil aviation. Following the agreement, the International Civil Organisation (ICAO) was built.

Art. 1 CHI states that "The contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory". The claim of every state having a sovereign power over the airspace above its territory contradicts the nature of aviation, which is, by definition, international. To allow international aviation, states need to negotiate for multilateral agreements and/or bilateral aviation conventions. Therefore, the preamble of the CHI states that "the undersigned governments [have] agreed on certain principles and arrangements in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically."

The preparations for the conference of Chicago had started when the ending of World War II was conceivable. On 1 September 1944, the United States invited to a diplomatic roundtable in Chicago to discuss the future of the aviation industry. Before the negotiations had started a multilateral system of traffic rights was aspired (Wenglorz, 1992).

The United States disposed of an extraordinarily strong military aviation force (300,000 aircrafts) after World War II – including countless transportation aircrafts. Those, they could easily convert into a civil armada. With this in mind, the US delegation argued in favour of open skies. Britain, in contrast, wanted an orderly market development (Larsen et al., 2006), meaning a contract that regulates all aircraft transport services. In bilateral aviation agreements, important factors in the competitive environment should be negotiated – the number of seats, the type of aircraft, the frequency of flights, the routes, the rights to land, etc. In contrast to this British scheme was the idea of a worldwide opening of the aircraft transportation market (open skies) (Larsen et al., 2006).

Due to the differing positions, long-lasting and difficult negotiations about the "eight freedoms of the air" were necessary (refer to ▶ Chap. 11 of this book) (Wenglorz, 1992).

2.2.4 Development of Quality and Cost 1945–1971

Commercial aviation took hold after World War II, using mostly ex-military aircraft in the business of transporting people and goods. Within a few years many companies existed, and flight routes criss-crossed North America, Europe and other parts of the world. This development was accelerated by the glut of heavy and super-heavy bomber airframes, like the B-29 and Lancaster, which could easily be converted into commercial aircraft. The DC-3 also permitted easier and longer commercial flights. The first North American commercial jet airliner, the Avro C102 Jetliner, flew in September 1949 shortly after the British Comet. By 1952, the British state airline BOAC had introduced the De Havilland Comet into scheduled service. While it represented a technical achievement, the plane suffered a series of highly public failures. The shape of its windows led to cracks due to metal fatigue which was caused by cycles of pressurisation and depressurisation of the cabin, and eventually led to a catastrophic failure of the plane's fuselage. By the time the problems were overcome, other jet airliner designs had already taken to the skies.

The USSR's Aeroflot became the first airline in the world to operate sustained regular jet services with the Tupolev Tu-104 on 15 September 1956. Boeing 707, which established new levels of comfort, safety, and passenger expectations, ushered in the age of mass commercial air travel as it is enjoyed today.

Even after the end of World War II there was still a need for advancement in aircraft and rocket technology. Not long after the war had ended, in October 1947, Chuck Yeager took the rocket-powered Bell X-1 past the speed of sound. Although anecdotal evidence exists that some fighter pilots may have crossed the sound barrier while dive-bombing ground targets during the war, this was the first controlled level flight to achieve this. Further barriers of distance were overcome in 1948 and 1952 as the first jet crossing of the Atlantic was conducted.

In 1961, the sky was no longer the limit for manned flight, as Yuri Gagarin orbited the planet within 108 minutes. His achievement heated up the space race, which had started in 1957 with the launch of Sputnik 1 by the Soviet Union, even further. The United States responded by launching Alan Shepard into space on a suborbital flight in a Mercury space capsule. With the launch of the Alouette I in 1963 Canada became the third country to send a satellite into space. The space race between the United States and the Soviet Union would ultimately lead to the current pinnacle of human flight, the landing of men on the moon by Neil Armstrong in 1969.

However, this historic achievement in space was not the only progress made in aviation at this time. In 1967, the X-15 set the air speed record for an aircraft at 4534 mph or Mach 6.1 (7297 km/h). This record still stands as the air speed record for powered flight, except for vehicles designed to fly in outer space.

An important driver of the future economic development of the industry was the development of wide body aircraft like the Boeing 747 (first flight 1969) or DC 10 (1970) or the Lockheed Tristar (also 1970). These planes allowed to transport up to 500 passengers instead of 150 which allowed significant economies and reduced cost but also required new markets and business models to fill the planes. In 1975, commercial aviation progressed even further when the Soviet Aeroflot started regular service on Tu-144 – the first supersonic passenger plane. In 1976, British Airways inaugurated supersonic service across the Atlantic, courtesy of the Concorde. A few years earlier the SR-71 Blackbird had set the record for crossing the Atlantic in less than 2 hours, and Concorde followed its footsteps with passengers in tow.

At the same time commercial aviation became more reliable and the industry grew. Airlines were established and route networks were set up. The following figures (◘ Figs. 2.1 and 2.2) show the development of Swissair as an example for a flag carrier of a neutral state and its route networks from the 1930s to the 1970s. The network evolved from a European point-to-point network to a hub-and-spoke network with connections through the hub Zurich Airport. First, some European destinations were served.

The following figure (◘ Fig. 2.1) illustrates the development from a point-to-point network to a raster network. As the planes became bigger, they allowed for more passengers to be transported. This development enabled the airlines to offer several destinations on one route by "milk can flights" landing and (un)loading

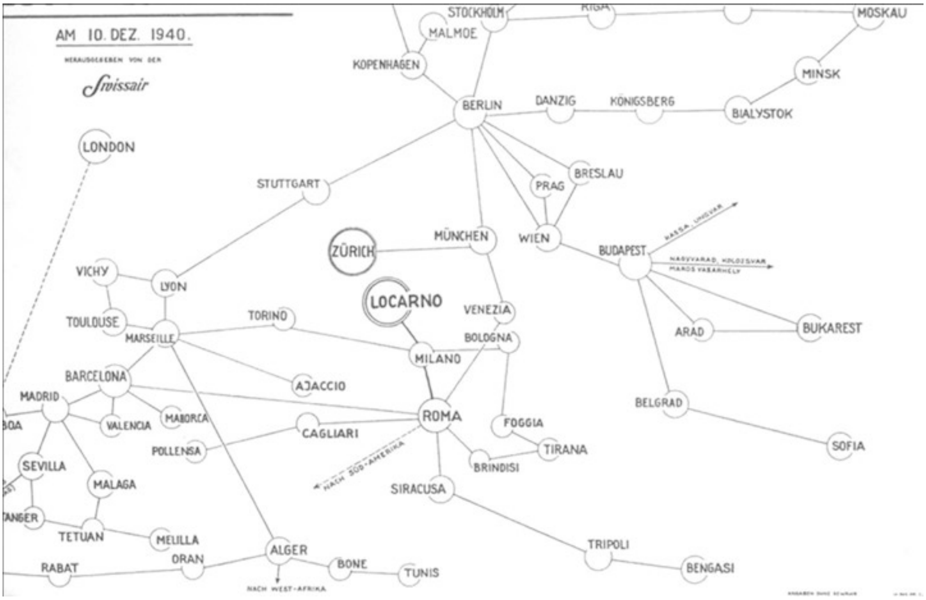


Fig. 2.1 Swissair routes in the early 1940s during World War II. (Schroeder, 2002)

Fig. 2.2 Swissair routes in the 1980s. (Schroeder, 2002)

passengers, which meant that they could serve more passengers in a small market and thus finance their operation.

Figure 2.2 shows the hub Zurich located in the centre and European domestic connections going through the hub Zurich to long-haul destinations. With the establishment of the long-haul market, it became important for airlines to have enough passengers to fill the large long-haul planes. Therefore, short- and long-haul flights were connected.

The route development of Swissair, as illustrated in the following route network figure (◘ Fig. 2.2), was a consequence of deregulation. The competitive environment changed and led to competitive prices and more efficient network management in the airline business.

2.2.5 Deregulation, Networks, Alliances and Low-Cost Operations 1974–1990

2.2.5.1 Deregulation of American Air Transport

The regulation of aviation was questioned strongly in the 1970s and 1980s. On the one hand, this was based on the general critique concerning the regulation policy of the government stemming from new economic approaches like the "contestable markets" approach (Baumol et al., 1982). On the other hand, the aviation industry found itself in a serious crisis: the oil crises lead to higher fuel costs; simultaneously there was a low demand for flights due to the recession and airlines had considerable debts from investments in wide-bodied aircrafts.

At this time, countless government regulations existed which aimed at securing an area-wide supply and avoiding too strong a competition that would ruin the aviation market. However, these regulations led to a favouritism of large airlines and a slackening of competition (Grundmann, 1998). Although flight prices were high, airlines did not achieve returns. As a consequence, and to meet the rising political pressure, the Airline Deregulation Act was signed in 1978 (Pompl, 2007). This was the beginning of the deregulation of the inner-American air traffic between 1979 and 1983 (Schäfer, 2003), in which the regulations concerned with market access, capacities and prices were abandoned.

This was an important development because, from then on, the United States actively aimed at deregulating the aviation market. The so-called Open-Sky policy of the United States strived for the signing of agreements with other states which then got the permission for the third, fourth and fifth freedom: opportunity of code-sharing, capacity for free tariffs, freedom in the appointment of capacities and frequencies (Schäfer, 2003).

The impacts of deregulation on the American market have been assessed in countless studies and have been discussed controversially. In the following, the decisive effects for the airlines (supply) as well as for the consumers (demand) are presented.

2.2.5.2 Supply

Especially the deregulation of prices in conjunction with the reduction of entry barriers led to fierce price pressure through new market entries for existing airlines. Therefore, in the first 8 years after the abolition of regulations, 200 new airlines were founded. Many of those newly founded airline companies quickly became victims of the strong competitive pressure. Approximately two thirds of the newly founded airlines disappeared from the market because they ceased business, were absorbed or involved in mergers (Pompl, 2007). Consequently, the concentration within the aviation industry rose. Prior to the deregulation, the eight biggest airlines possessed 81 percent of the domestic market, which shifted to 95 percent by 1991 (Dempsey & Goek, 1992). The rise in economic pressure from competition and the high number of mergers during that period show that economies of scale, scope and density had been idle and could be fully utilised after the deregulation of the market.

Altogether the first 5 years of deregulation were characterised by bad revenues in the airline industry. The American airlines lost USD 900 million and suffered from the worst profit situation the aviation industry had ever experienced (Pompl, 2007). In this context, it is important to remember that the general economic climate was marked by a recession and the second oil crisis. Therefore, the situation for the aviation industry was difficult worldwide.

The airlines confronted with competitive pressure reacted by massively cutting costs, mainly labour costs. As a result, the real unit labour costs fell by more than 50 per cent in the period between 1978 and 1984. In contrast, the decline in Europe only amounted to 15 percent (Card, 1996).

Besides introducing cost cuts, airlines also adapted their business models and strategies towards the new competitive environment. In particular the new competitors were forced to position themselves in niches. The "no frills" concept and the introduction of low-cost carriers are supply strategies which have developed into a widely spread concept among airlines.

The pressure, however, also opened up new opportunities for increased flexibility which led to an augmentation of productivity. The flight routes could be restructured and adjusted to better suit customer needs. Since price regulations had been abolished, price differentiation became possible. The newly founded airlines in particular profited from the fact that their employees were not unionised and that they could, therefore, cut costs thanks to more flexible conditions of employment and lower wage levels (Baltagi et al., 1995). The emergence of hub-and-spoke networks was also a development promoted by the deregulation. The canalisation of routes through hub-and-spoke networks allowed for cost cuts, while the mounting of hubs also led to a natural monopoly for certain airlines at the different locations. These airlines could avoid the price pressure up to a certain degree (Card, 1996). Except for three cases, all hubs were controlled by airlines that generated at least 60 percent of all flights, gates and passengers (Dempsey & Goek, 1992).

In the air passenger market, the competition among national airlines increased. National airlines charged high amounts for tickets and were supported by their governments. They operated in a controlled environment, where they had monopolies in their countries. With the deregulation in the United States, prices started to decrease and the first low-costs carrier (Southwest Airlines) was founded in the United States in 1971. In Europe, the deregulation process took much longer. Price competition started in Europe in the 1980s. Several low-cost carriers commenced their operations in Europe following the start of the price competition and new business models emerged with different cost allocations. New pricing schemes were introduced which followed new booking behaviours using internet booking services.

The large airlines adopted computer-based reservation systems as an entry barrier for new suppliers. They used these computer-based reservation systems as a marketing instrument and paid commissions to travel agencies for using the systems prohibiting the use of competing systems. The travel agencies could request price information and capacities, as well as carry out bookings in these systems. These developments increased the concentration on only a few airlines (Kennet, 1993). Frequent flyer programs also emerged during that time – another measure of customer loyalty which boosted big airlines.

In general, the supply developed positively with rising demand. Between 1978 and 1988 the number of passengers increased by 88 percent and the kilometres flown by passengers rose by 62 percent. The supply, in the form of available seat kilometres, rose by approximately 65 percent during the same period (Kennet, 1993).

2.2.5.3 Demand

The consumers are often considered the real beneficiaries of deregulation because it resulted in lower flight prices and flying as a former luxury good becoming a commodity. In fact, the prices sank by 22 percent on average between 1978 and 1993 (Morrison & Winston, 1997). In addition, a large number of passengers was able to benefit from lower prices. In the year 1989, for instance, 89 percent of all passengers benefited from an average price reduction of 89 percent (Pompl, 2007). Prior to the deregulation a decrease of flight prices would already have been possible through technical advances, i.e. the introduction of large capacity aircrafts, but it was forwarded further by the deregulation.

The increased number of flights and air connections after deregulation also meant that customers had a greater choice of offers to choose from (Pompl, 2007). Additionally, the hub-and-spoke systems were established and increased connectivity of travellers for lower prices. The hub-and-spoke system, however, also led to higher prices at the hubs. In 1988, the average prices at the 15 most frequently passed hubs were 27 percent higher than the prices at the 38 not-concentrated airports (Dempsey & Goek, 1992). One reason for this is the market power of the dominant airlines at different locations. As a consequence, prices for air travel which ended at hubs became more expensive in comparison with prices for connecting flights towards hubs. The major competition and, consequently, the decrease in prices happened on those routes that were direct connections with much traffic (Button, 1996).

Overall, the service offering has increased because of the differentiation of performance; however, a distinction has to be made between hubs and remote areas. Although at large, the number of offered flights has increased, since the deregulation, smaller towns are generally only serviced by one airline and, therefore, the availability of flights is worse for those regions. However, the number of hubs has increased and thus the number of non-stop connections has also risen.

Then again, the increase of the total number of flights has also led to a capacity overload and consequently, the number of delayed flights and the noise exposure in the area surrounding the hubs have increased. Furthermore, passengers have to cope with having to spend more time on aircrafts and airports.

In general, studies on deregulation conclude that, on average, consumers have benefited distinctively from lower flight prices and higher service offerings. It is estimated that consumers saved up to USD 11 billion in the year 1986 alone (Kahn, 1988).

2.2.5.4 Deregulation of the European Air Transport

In Europe, the same development happened with a time lag of 15 years. Since 1993 freedom of services has existed in European aviation, and since 1997 full cabotage has been allowed in the framework of the third liberalisation package. Since that year there is an actual domestic market for aviation among the members of the European Union (EU). The delay of the deregulation development in Europe is due to the heterogeneous structure of the European Union which did not allow for an implementation at the same pace as in the United States.

Besides the harmonisation of the law and the deregulation, accompanying measures were implemented. Therefore, in view of the higher number of flight delays and cancellations, passenger rights were strengthened. Furthermore, a number of regulations concerned with flight noise emissions were implemented and flight security was further Europeanised (O'Reilly & Stone Sweet, 1998).

Still, the European market cannot be referred to as a liberalised market. There are still countless regulations which have an impact on the aviation industry. In particular, the following are significant (Heitmann, 2005):

- The regulation of extra-European routes and extra-European airlines.
- The regulation of the access to lean airport capacities.
- The hindrance of pan-European fusions.
- The payment of open and hidden subsidies.

Because of the structure of the European aviation, deregulation was implemented over a longer period of time and has different impacts compare to the impacts deregulation has had in the United States. Those differences are explained in the following.

2.2.5.5 Differences Between the European and American Markets

Unlike the US aviation industry, which was affected by private companies from its very beginning (Grundmann, 1998), the European aviation industry was always heavily influenced by governmental interventions and governmentally funded companies.

The liberalisation of the European civil aviation industry was an evolutionary process, whereas the Deregulation Act constituted an abrupt change in policy. Incremental developments give advantages to small companies entering a market, as they may provide a chance for consistent development (Martinez et al., 2001).

As mentioned before, the political process of deregulation is significantly different to the one in the United States. The European Union is a collective of sovereign states which makes deregulation to a process of negotiation. Due to differing interests of various states, deregulation was only slowly implemented. The majority of states had a governmentally funded flag carrier and an infrastructure they wanted to protect. These national interests were reasons for the gaps in deregulation pointed out earlier. These regulations lead to an inefficient deregulation process.

The structure of airlines in different nations and the state funding scheme of those states differ significantly. The company culture, the terms of employment and the claims of the environment differ between the US and EU regions. A further difference may be noticed in the structure of customers. Customers in the US market are relatively homogenous, whereas European airlines have to cope with customers that have heterogeneous demands and differ in their cultural backgrounds.

A significant difference also exists in the hub-and-spoke systems. In contrast to the US system, in Europe these systems are nationally coined. Although since 1997, when cabotage has been permitted, the possibility exists to establish hubs at optimal locations outlying the home market, this possibility is strongly limited by the stringency of slots.

Strong network carriers with big home markets strengthened their hub-and-spoke networks searching for economies of scale, scope and density by growing organically or by mergers and acquisitions. Instead of merging with other airlines, the national airlines in Europe in the 1990s went for alliance systems Lufthansa, for example, decided to start loose alliance networks by founding the Star Alliance. Wide-body planes, such as the Boeing 747, the DC 10 and the MD 11, were generating profits on long-haul routes.

At the same time the growing leisure market charter airlines became more popular and were more and more integrated into tour operators. The latter offered the tourist the whole value chain, from the transportation to the holiday destination, to the stay in the destination as well as the transportation back to his/her home.

2.2.6 New Perspectives – Customer Value 1991–2005

During the 1990s, especially in Europe further deregulation took place. Today, online sales channels have become more efficient and are very popular. Under the pressure of an increasing number of low-cost carriers on short-haul routes as well as international threats such as wars, epidemics and terrorism, network carriers had to become more efficient to be able to survive in a liberalised market which is dominated by prices. Network management was intensified. Alliances grew independently, while mergers started even across borders. The path through alliances towards mergers seems to be a successful one. Best examples for this are the integration of Swiss International Airlines into Lufthansa in 2005 and KLM into Air France in 2004. The trend moves towards continental hubs.

More and more the legacy carriers in the traditional western countries running on a hub business model see competitors from new countries especially in the Middle East. Emirates with Dubai or Qatar with Doha, but also Turkish with its newly opened big airport in Istanbul operate intercontinental hub models drawing on their excellent geographical location between Europe and Asia. Based on the strong economies (economies of scale and networks) it can be expected that in future the hub business model will see an even stronger consolidation into a system of so-called mega carriers like Emirates Airlines, Lufthansa, British Airways, Air France/KLM with their "satellite" airlines. Or they become niche players with smaller networks focusing on specific routes or a specific group of travellers (e.g. La Compagnie, Peoples Airlines, Helvetic Airways).

Low-cost airlines developed an anti-network model, a so-called point to point model, which has been successful on the domestic and continental markets around the globe for several years and enticed away passengers from existing network carriers. In addition, this business model managed to attract new target groups for low-cost trips within continents, consisting partly of those persons who had never flown before. Developments indicate that there even might be a market for long-haul low-cost travel as Norwegian has launched low-cost long-haul routes from Europe to North and South America and Asia. However, the sustainability of the long-haul low-cost market is yet unclear, as Norwegian has repeatedly reported losses, partly attributable to problems with their long-haul operations (Norwegian 2019). Long-haul low-cost operations seem to work fine with flight times up to 8 hours, so in the case of Norwegian for the routes between Europa and the eastern part of North America. Longer flights to Asia and South America cannot achieve the cost structure needed and passengers needed to be successful. Reasons for this might be that up to 8 hrs passengers can cope with reduced board service and smaller, cheaper aircrafts like the A321neo can be used, which have a limited fuel capacity and range.

Due to high numbers of new low-cost airline entries in the market, consolidation is becoming an issue among low-cost airlines. In recent years, takeovers have occurred more frequently than they used to. Also mixed business models (between point-to-point and hubbing) proved difficult as carriers such as Air Berlin have failed.

2.2.7 New Materials and Technologies 2006–2018

In commercial aviation, the early-twenty-first century has seen the end of an era with the retirement of the Concorde. Supersonic flights turned out not to be commercially viable, as the planes had to fly over the oceans if they wanted to break the sound barrier. Furthermore, the Concorde featured high fuel consumption and could only carry a limited number of passengers due to its highly streamlined design. New developments in the area of supersonic flight can be recognised; however, for an airline, they are not yet at a sustainable level for implementation. The end of the supersonic period in commercial aviation might be considered a symbol for a move to more sustainability and pragmatism in the industry.

After Open Skies Agreements had been relaxed in the United States, they also have been further relaxed in Europe. This had an impact on connectivity and pricing of airline tickets. In the future, new pricing schemes are likely to be evaluated and implemented. As prices are increasing due to overfilled airspaces and airports and also due to high fuel costs, a seamless customer service becomes a highly relevant issue. A new level of quality is required in premium classes (business and recently also premium economy) which are growing in their popularity and represent the business field of network carriers which is most profitable. Consequently, some airlines introduced new aircraft, even all-business class aircraft, to the market. Together with rising environmental awareness and for some periods high fuel prices lead to a focus on fuel efficiency and environmental quality.

This was possible due to new technologies produced by Airbus and Boeing. Airbus brought the A380 flagship on the market which can realise huge economies of scale in a full economy-class configuration with over 800 seats on board. Boeing produced the Boeing 787 Dreamliner, which is the first commercial airplane produced to a great extent with lightweight carbon material. Due to its lower weight the rather small Dreamliner can operate new routes point to point in a long-haul market to competitive prices and by this compete with better direct connections also from secondary hub airports, whereas the A380 is the plane for the big mega hubs and large transfer passenger numbers. Both concepts support different business models and come along with significant fuel efficiency.

Mini Case: easyJet and the Implications of Brexit

By Andreas Wittmer

Since its inception in 1995, easyJet has grown to become one of Europe's leading low-cost airlines carrying over 96.1 million passengers p.a. using a fleet of 331 aircraft throughout Europe. Initially launching operations in the United Kingdom, easyJet rapidly expanded beyond its London Luton hub into the European market, operating from 30 bases across Europe (easyJet, 2019).

The access to the European market was provided by the basis of the airline's ownership by EU nationals which afforded them the 9 freedoms agreement giving them the allowance to fly anywhere within the EU without restrictions. This free market access forms part of the European Common Aviation Area (ECAA) together with standardised regulations, e.g. air crew licensing or air traffic management. Furthermore, easyJet benefitted from the bilateral agreements signed between the EU and third countries. All these privileges are currently at stake with the impending Brexit, the United Kingdom's departure from the EU (KPMG, 2016).

These are the primary problems that easyJet is facing, besides a recession in the United Kingdom or other smaller aspects such as slot management (easyJet, 2019). After Brexit, easyJet's ownership would consist mainly of non-EU nationals, thus eliminating these traffic rights. As such, easyJet would be dependent on the United Kingdom government re-negotiating the United Kingdom's access to the European aviation market such as re-applying for an ECAA membership or signing bilateral agreements. Another option for easyJet is transferring its European operations to a separate entity with an EU operating license, thus granting them the traffic rights with the EU as well as to other countries covered by agreements (KPMG, 2016).

For easyJet, the latter option proves to be viable, with the airline opening a subsidiary in Austria to secure traffic rights in the event of a "no-deal Brexit." This includes the transfer of aircraft, pilots and cabin crew to the new subsidiary. Additionally, they created a second spare parts hub in the EU to prevent any supply chain issues (Kaminski-Morrow, 2019). Regarding the ownership issues, easyJet is prepared to use its right to force non-EU shareholders to sell their shares in order to achieve the 50% plus one EU-national ownership requirements (easyJet, 2019). As such, the company has implemented several measures to maintain the fundamental aspects of their business model challenged by the impending Brexit.

2

2.2.8 2019 + Environment and New Fuels

Further development, in the beginning of the twenty-first century, until the Corona Crisis in 2020 has been driven by a strong economic development with growing demand and, also because of new entrants like the Gulf carriers, supply. There is now a clear picture of the long-term consequences of the Corona Crisis. The short-term lock down effects which lead to a quasi-complete stop in passenger traffic (with the exception of repatriation flights) for several months already lead to bankruptcies of mainly smaller airlines and a need for state support (with growing influence of governments on airline management) even for large and strong airlines like Lufthansa. In the long-run most forecasters see a reduction of business traffic but a close to complete come back of leisure traffic (IATA, 2019, own research, 2021).

Together with the Corona Crisis awareness of the climate crises grew. Many governments introduced new environmental taxes to reduce carbon effects of aviation (e.g. Swiss government CO_2 charges between CHF 30 and 120, Austrian government, minimum price) also in summer 2020. The combined effect of coping with a transition stage until a new normal and a new normal with possibly less business traffic and an increased environmental awareness will affect the business models of airlines and the whole aviation industry. Important elements of this change might be made possible by new technologies.

Aviation has focused on remotely operated or completely autonomous vehicles. Several unmanned aerial vehicles or UAVs have been developed. In April 2001, the unmanned aircraft Global Hawk flew from Edwards AFB in the United States to Australia non-stop and without being refuelled. It took 23 hours and 23 minutes and was the longest point-to-point flight ever undertaken by an unmanned aircraft. In October 2003, the first completely autonomous flight of a computer-controlled model aircraft occurred across the Atlantic. In Switzerland, post offices have started using quadrocopters to transport blood samples between laboratories in 2019, hoping to eventually use the technology to deliver mail.

The Airbus A380 will not be produced anymore from 2021 as it has proven not to be successful with its cost and emission perspectives. Markets are not big enough to generate the needed load factors in line with the needed prices. Furthermore, the plane technology and the engine technology are not up to date and too expensive to be upgraded in a saturating market in the United States and Europe. Furthermore, limited airspace, airport infrastructure and climate awareness and policies will have an impact on demand of air travel. Whereas limited airspace and airport space are arguments for bigger planes such as the A380, the market and environment aspects are countering strong and airlines moved to order more of the new technology planes such as the Boeing 787 Dreamliner and the Airbus A350.

The main topic in society of this time period will be the climate impacts of aviation. Aviation is a significant and growing contributor to the environment by its emissions. It has become heavily under pressure by especially younger generations blaming aviation for climate change. In research there is a high pressure on the development of new engine technologies using electricity (electric engines) and new carbon-neutral fuel. Furthermore, the society less and less accepts short-haul flights, which can be substituted by trains. Airlines start to cooperate with railway companies to replace direct or feeder flights by railway options, e.g. Swiss and Swiss Federal Railways operate the transport from Lugano to Zurich by train. Emirates has gone into a partner agreement with the French TGV railway company to transfer its passengers by TGV from Paris to the different destinations in France.

The more intramodality will become normal, the more challenged will be the point-to-point airlines (low-cost Carriers). Their business case only works on short-haul routes. In Europe many of these short-haul routes can be assessed by rail and high-speed rail. Due to more and more airspace and airport congestion, travel time by rail is not longer for rail travel of up to 4 hours. With state policies increasing travelling cost by plane (e.g. Austria introduced a minimum price of EUR 40 from Vienna, Switzerland introduces a CO_2 charge of min CHF 30 for short haul flights), and subsidies for railways (e.g. Austria supports newly very cheap rail travel passes) the competitive disadvantage of trains versus planes will be reduced and as research shows that the most important decision factor for travellers is the price or total travel cost, it can be assumed that short-haul growth of air travel in Europe will come to an end. Additionally, some governments and companies have made new rules about minimum travel times by air for their employees (e.g. Swiss government up to 6 hours travel time by train).

By the year 2050, one can expect to live in a world with carbon-neutral aviation operation, but most likely not carbon neutral footprints including production and recycling planes and airports.

2.3 Size of the Aviation Industry

This section provides an overview and some statistics of the aviation industry based on different data sources. The largest airlines in the world can be found in the Unites States. Operating over 330,577 million revenue passenger kilometres (RPK) each year (IATA, 2019), American Airlines is the largest passenger airline in the world. Federal Express (FedEx) is the largest scheduled freight transporter with almost 17,499 million freight ton kilometres. The second and third largest passenger airlines are also American airlines; Emirates ranks fourth. Southwest Airlines ranks fifth, China Southern Airlines ranks sixth and Ryanair ranks seventh, being the biggest European Airline with respect to RPK. The ranks and passengers carried are presented in ◘ Table 2.1.

2

Table 2.1 Top 10 passenger and cargo airlines in 2018

Total revenue passenger kilometres flown			Total freight tonne kilometres flown		
Rank	**Airline**	**Millions**	**Rank**	**Airline**	**Millions**
1	American Airlines	330,577	1	Federal Express	17,499
2	Delta Air Lines	330,034	2	Emirates	12,713
3	United Airlines	329,562	3	Qatar Airways	12,695
4	Emirates	302,298	4	United Parcel Service	12,459
5	Southwest Airlines	214,561	5	Cathay Pacific Airways	11,284
6	China Southern Airlines	200,239	6	Korean Air	7839
7	Ryanair	170,900	7	Lufthansa	7394
8	China Eastern Airlines	166,282	8	Cargolux	7322
9	Air China	161,199	9	Air China	7051
10	Lufthansa	158,986	10	China Southern Airlines	6597

IATA (2019)

When airlines are ranked according to the group revenues, a different picture emerges. American Airlines is top of the ranking ahead of Delta Air Lines, Lufthansa Group and United Continental. This emphasises the structure of the airline industry around the world with revenue being considerably higher in the American (because of an earlier consolidation) as opposed to the European and Asian markets. In contrast, the growth in revenue is low for American airline groups as opposed to their European or Asian counterparts. European airline groups are currently going through a phase of consolidation, thus enhancing growth. Table 2.2 shows the revenue of the top 20 ranked airlines in the years 2017 and 2016.

However, airlines and freight forwarders are not the only important partners of the aviation industry. Airports handle all passengers and represent the key infrastructure for the industry. Atlanta, which is the largest airport in the world, handles over 107 million passengers each year. Beijing, the second largest airport, handles almost 101 million passengers and Dubai being the third largest airport, handles more than 89 million passengers each year. Table 2.3 provides an overview of the 20 largest airports in the world. A new player in the European arena is Istanbul with its new airport opened in 2019 capable of handling 90 million passengers and up to 200 million passengers once all future phases are completed by the year 2028.

The size of airports can also be looked at from the perspective of total movements per year. Ranking airports according to this perspective shows that Atlanta handles almost one million movements, which represents the largest number of departures and landings of all airports worldwide. Considering the perspective of movements, Amsterdam, which ranks ninth on the world ranking list, is the largest

Table 2.2 Top 20 airline groups based on revenue 2017

Ranking	Airline group	Revenue US$m		% Change
		2017	2016	
1	American Airlines	42,207	40,180	5.0
2	Delta Air Lines	41,244	39,639	4.0
3	Lufthansa Group	40,449	34,912	16.2
4	United Continental	37,736	36,556	3.2
5	FedEx	36,172	27,358	32.2
6	Air France-KLM Group	29,313	27,398	7.0
7	Emirates Group	27,882	25,779	8.1
8	International Airlines Group	26,116	24,885	4.9
9	Southwest Airlines	21,171	20,425	3.7
10	China Southern Airlines	18,987	17,272	9.9
11	Air China	18,425	17,297	6.5
12	ANA Holdings	17,805	16,298	9.2
13	China Eastern Airlines	16,335	15,679	4.2
14	Air Canada	12,534	11,094	13.0
15	Japan Airlines Group	12,490	11,900	5.0
16	Cathay Pacific Group	12,480	11,950	4.4
17	Qantas Group	12,103	11,777	2.8
18	Singapore Airlines	11,693	10,737	8.9
19	Qatar Airways Group	11,597	10,816	7.2
20	Turkish Airlines	11,185	9871	13.3

Table compiled by the author based on Flightglobal (2017, 2018)

European airport. American airports take seven of the first ten positions. Table 2.4 shows the movement rankings of the largest airports worldwide.

These data all present the historical development of the airlines and airports mentioned. However, for economists and managers an important question is "how the future will develop." Airbus, for example, has looked at the scheduled world air traffic today and compared it to forecasts made in regard to the year 2038. In 2018, the big air transport market has recently shifted from the United States to the Asia-Pacific region. By 2038, it is expected to move even more towards other continents. Throughout all of the continents, a general growth trend can be expected. Of all these, the Asia-Pacific region is expected to experience the highest growth, where in future over 50% of the world's biggest traffic flows will be involved in. Other emerg-

2

Table 2.3 The largest airports in the world based on total number of pax handled 2018

Rank	City	Code	Total passengers	% Change
1	Atlanta GA	ATL	107,394,029	3.3
2	Beijing	PEK	100,983,290	5.4
3	Dubai	DXB	89,149,387	1.0
4	Los Angeles CA	LAX	87,534,384	3.5
5	Tokyo Haneda	HND	87,131,973	2.0
6	Chicago O'Hare IL	ORD	83,339,186	4.4
7	London Heathrow	LHR	80,126,320	2.7
8	Hong Kong	HKG	74,517,402	2.6
9	Shanghai Pudong	PVG	74,006,331	5.7
10	Paris Charles De Gaulle	CDG	72,229,723	4.0
11	Amsterdam	AMS	71,053,147	3.7
12	New Delhi	DEL	69,900,983	10.2
13	Guangzhou	CAN	69,769,497	6.0
14	Frankfurt/Main	FRAU	69,510,269	7.8
15	Dallas/Fort Worth TX	DFW	69,112,607	3.0
16	Seoul Incheon	ICN	68,350,784	10.0
17	Istanbul Atatürk	IST	68,192,683	6.4
18	Jakarta	CGK	66,908,159	6.2
19	Singapore	SIN	65,628,000	5.5
20	Denver CO	DEN	64,494,613	5.1

Airports Council International (2019)

ing markets such as Latin America and Africa are also expected to experience higher growth rates. In addition, the Middle Eastern area is expected to realise an increase in the volume of passengers carried and movements in the next few years. This is particularly evident in the growth forecasts for the world traffic flows, where the highest growth rates are either within or between these highest growing markets. On the other hand, Europe, North America and CIS will be experiencing slower growth. Figure 2.3 illustrates the compound annual growth rate per region in regard to the number of revenue passenger kilometres (RPKs) between 2018 and 2038. Figure 2.4 illustrates the shares of RPK between different areas of the world in the year 2000 and the year 2020. RPKs are the revenues per passenger per kilometre.

Table 2.4 The largest airports worldwide according to the number of movements in 2017

Rank	City	Code	Total movements	% Change
1	Atlanta GA	ATL	879,560	(2.1)
2	Chicago IL	ORD	867,049	(0.1)
3	Los Angeles CA	LAX	700,362	0.5
4	Dallas/Fort Worth TX	DFW	654,344	(2.7)
5	Beijing	PEK	597,259	(1.5)
6	Denver CO	DEN	574,966	1.7
7	Charlotte NC	CLT	553,817	1.5
8	Las Vegas NV	LAS	542,994	0.3
9	Amsterdam	AMS	514,625	3.6
10	Shanghai Pudong	PVG	496,774	3.5
11	Paris Charles De Gaulle	CDG	482,676	0.7
12	London Heathrow	LHR	475,915	0.2
13	Frankfurt/Main	FRA	475,537	2.7
14	Toronto Pearson ON	YYZ	465,555	2.0
15	Guangzhou	CAN	465,295	6.9
16	Istanbul Atatürk	IST	460,785	(1.2)
17	San Francisco CA	SFO	460,343	2.2
18	Tokyo Haneda	HND	453,126	1.0
19	Houston TX	IAH	450,383	(4.3)
20	Mexico City	MEX	449,664	0.3

Airport Council International (2019)

Airports and airlines are not the only representatives of the aviation market. Further suppliers play a significant role in the aviation industry along the supply chain: manufacturers, e.g. Boeing and Airbus, which depend on orders of airlines, maintenance, leasing, ground handling, reservation system providers, catering and fuelling organisations and travel agents. All those suppliers generate their incomes entirely or at least to some extent from the aviation industry. The Aviation Ecosystem (Rencher, 2019) reaches far beyond with companies in the finance, consulting, engineering, furniture and service sector influencing innovation and development of the industry. The indirect, catalytic effects like enabling transport and contribution to the attractiveness of places (Littorin, 2015) highlights the relevance of the aviation industry for the whole economy.

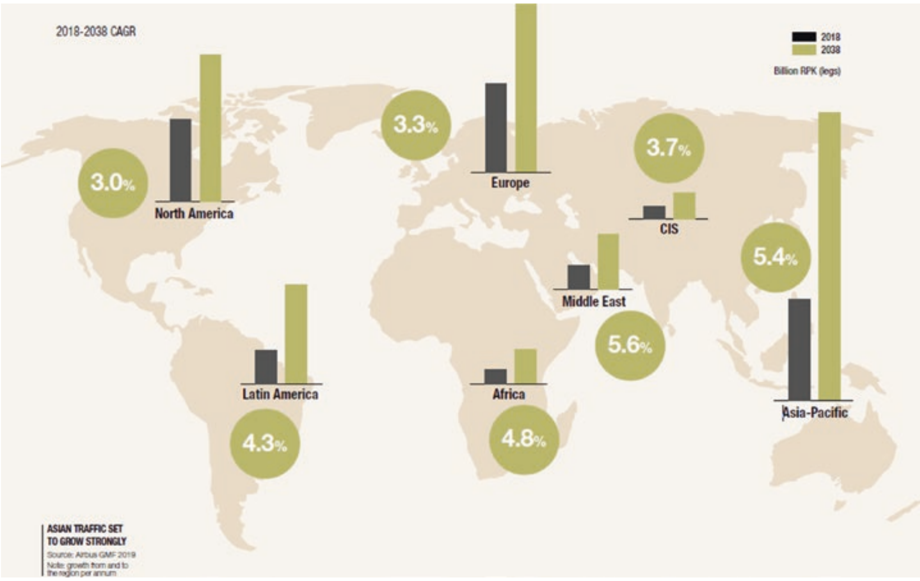


Fig. 2.3 World air traffic flow in the year 2018 and 2038. (Airbus, 2019)

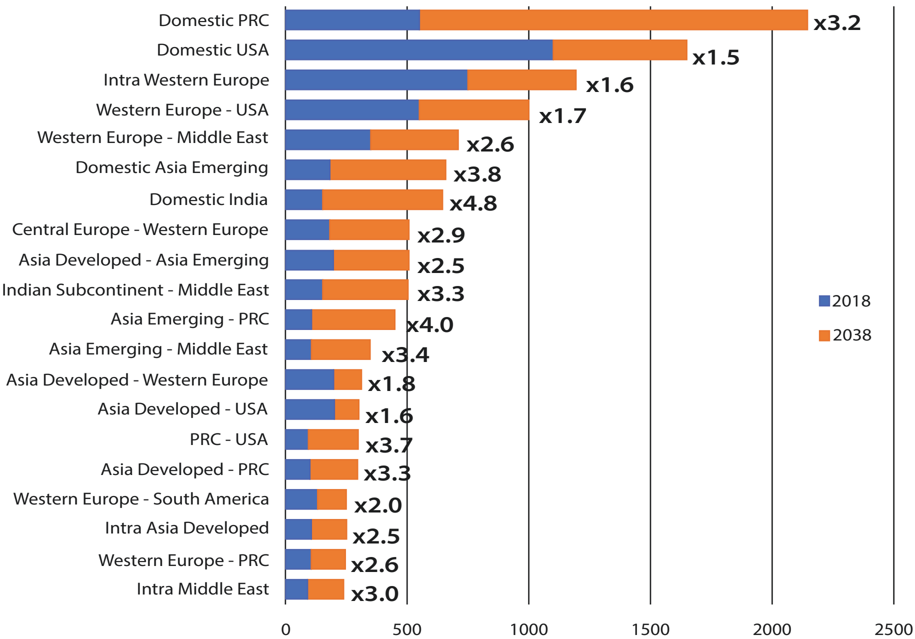


Fig. 2.4 World air traffic flow forecast from 2018 to 2038. (Airbus, 2019)

2.4 Structure of the Aviation Industry

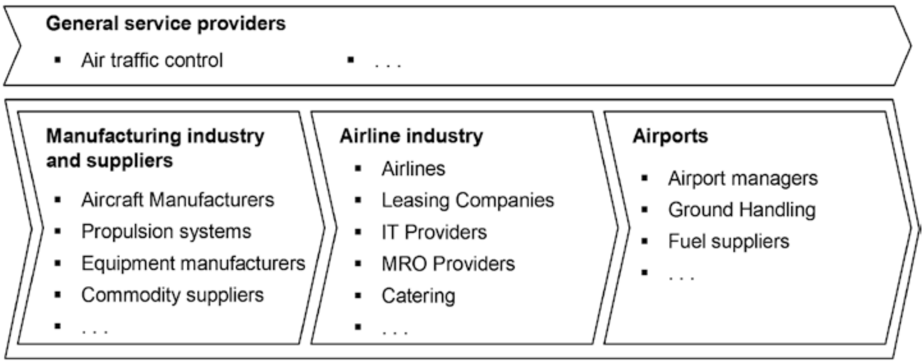
The aviation industry is a service industry providing transport services. Air transportation shows many characteristics which are typical for service industries, e.g. the intangibility and perishability of the product and the high importance of personal contact to the customer (Benkenstein et al., 2017).

As mentioned before, airlines and airports are the two main actors in the industry. Airlines offer the actual transport service; airports provide the ground infrastructure to handle aircraft movements. The manufacturing industry and aviation suppliers assemble aircrafts and provide spare products. As a provider of supplementary processes, the industry relies on general service providers such as air traffic control. ◘ Figure 2.5 illustrates the core value chain in the aviation industry.

This section provides an overview about the overall supply chain and industry competition structures. Each group of actors will be then be described in the following chapters.

Concerning the *general service providers*, the airline industry is characterised by monopolies for air traffic control services. The aircraft *manufacturing industry* forms an oligopolistic structure regarding small- and mid-sized aircrafts and a duopoly regarding the market for wide-body aircrafts. Manufacturers of smaller aircraft like Embraer or Bombardier merge (or try to) with these big manufacturers. New developers of medium haul planes have now come up in China (COMAC).

The *airline industry* is characterised by fierce competition. Airlines compete on a polypolistic market. On the one hand, the latter is characterised by low entry barriers and a variety of different business models. On the other hand, the airline industry is extremely capital intensive and comprises specific investments in long-term assets that create high exit barriers. While information technology (IT), maintenance, repair and overhaul (MRO) and catering providers are usually located nearby the respective airlines (commonly large airlines), the airline leasing market is dominated by two companies (duopoly). Oligopolistic structures occur in regard to airports, usually one or a few of them dominating whole regions or nations. At airports, often only limited competition exists concerning ground handling services. Fuel companies are structured in an oligopoly.



◘ **Fig. 2.5** The aviation industry value chain. (Author's own figure)

While airlines and airports are enclosed by the manufacturing and supplying industry on the upstream side, the final customer is located at the downstream side of the value chain. With the ascent of online booking and the decline of packaged travels and the role of tour operators, demand for air transport is fragmented.

2.4.1 New Competitors

As the airline market is characterised by low entry barriers and increasing market liberalisation, new competitors are a constant threat to existing airlines. However, not all new entrants are successful in building a permanent market position and thus may exit the market after some time (such as all-business carriers or long-haul low-cost carriers). The most important market barrier today seems the establishment of hubs and the limited slot capacities of the big airports. The allocation of slots, therefore, is an important factor of competition policy in the aviation sector. Finances today in the age of zero to negative interest rates are not a significant hurdle anymore. Leasing companies enable the establishment of new airlines. The establishment of "low-cost" airlines in the 1990s is an example for successful market entries.

Market entrance barriers of airports are much higher than the ones of airlines, due to extremely high initial infrastructure investments and even more the space and rights needed. As a consequence, the number of newly established airports remained rather low during the last years. In Europe, notable exceptions are the conversions of former military airfields into low-cost airports, whereas in Asia and the Middle East an exception is the emergence of all-new airports in the strongly growing traffic regions.

2.4.2 Substitutes

High-speed trains offer transportation alternatives and have an impact on airlines – and consequently on airports. On the one hand, high-speed trains may pose a threat to airlines, particularly on short-distance routes. On the other hand, however, they may also provide an opportunity for airlines and airports to alleviate air- and landside airport congestion and gain new customer groups. Thus, rail transport cannot be considered being a substitute for air transportation per se. A further potential threat to air transportation is the increasing usage of telecommunication technologies as a means for communication (such as videoconferencing). This technology might reduce the volume of passenger movement which was made possible by air transportation in the first place.

2.4.3 Customers

The demand side of the aviation industry can be distinguished between persons who are flying for business purposes (those passengers, who demand frequent flights to a wide range of destinations, seek service quality and are willing to pay a premium for these benefits) and leisure travellers (who seek the lowest prices and are less concerned about the service being offered, frequency of flights or the number of destinations being served). However, the group of airline passengers is becoming increasingly heterogeneous (Huse & Evangelho, 2007). The competition in aviation results in a high customer persuasion as consumers have the choice between different options for travelling and transportation providers.

In regard to the product, an extraordinary high transparency exists, as customers may compare prices and thanks to various internet platforms the quality of almost all products is available (e.g. Seatguru, to check for leg room). Even though the customer may choose from a large variety of sales channels (such as travel agencies, internet, telephone), the air transportation market is characterised increasingly by online distribution. The majority of sales will be direct sales, mostly via the airlines' digital channels such as websites and/or mobile apps. IATA's new distribution capability (NDC) is an example and shows the pressure the airline industry puts on global distribution system providers (e.g. Amadeus, Sabre, etc.).

Air freight in general is booked over the forwarder, who in turn reserves cargo capacity at an airline. Since key freight forwarders usually make the largest bookings, cargo airlines typically deal with a very small client base, which therefore disposes of a high bargaining power (Becker & Dill, 2007).

As mentioned, the air transportation industry's core value chain is part of the aviation ecosystem which itself is encompassed by a number of stakeholders. As the "outer-circle" shows, the air transportation industry as a whole is embedded in its environment (stakeholders). Major linkages exist to its ecological environment, to institutions and organisations, to its technological and economic environment as well as to its social system (see ► Chap. 2).

2.5 Special Characteristics of the Air Transport Market

The aviation industry features a number of characteristics which make it unique and distinguish it from other industries. As these peculiarities are fundamental to the industry and have implications on competition structures, the most important characteristics are introduced briefly:

- *Cyclicality of the industry development:* The aviation industry is characterised by a highly cyclical development of passenger and freight transportation. Years of high profits and strong demand are regularly followed by years of substantial losses. In general, the development of air transportation is coupled to the overall economic situation. Nevertheless, the cyclical up- and downturns in aviation appear to be amplified, i.e. more volatile than the overall economic development. The development of air cargo thereby is often found to feature a trend which is slightly ahead the development of the general economy. Therefore, it can be used as an indicator for the overall development of the economy (◘ Fig. 2.6).

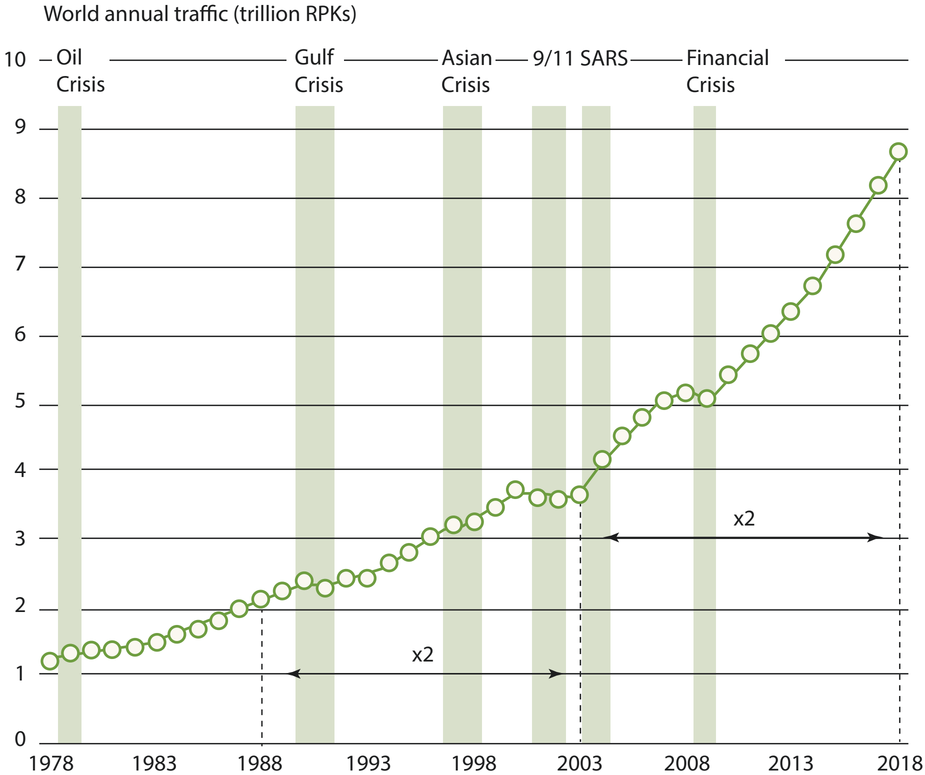


Fig. 2.6 Influence of external shocks on air travel in the long term. (Airbus, 2019)

On the one hand, the reasons for the high cyclicality in aviation lay in its external surrounding, with air transportation only reacting and following the overall state and development of the economy. On the other side, long supply chains and procurement cycles often lead to over- and under capacities. The time between the order of an airplane and the actual start of operations can take up to several years. Thus, an aircraft which has been ordered in an economic upturn often arrives in a recession and may even worsen this downturn. Inversely, intended capacity growth due to increasing demand might not completely be met, as there is only little possibility to respond quickly to increasing demand if airplanes, which have been ordered, are not delivered in time. Therefore, profit cycles are even more extreme than revenue cycles and are forerunning.

- *High fixed cost structure:* When compared to other industries, air transportation is characterised by a high fixed cost structure and rather low variable costs. Air transportation is an extremely capital-intensive industry with very specific investments in long-term assets that create high exit barriers.

  The reasons for this cost structure are high – and often very specific – investments at either manufacturers (development of new aircraft), at airlines (financing of new aircraft) or at airports (provision of ground infrastructure such as runways and terminals). Consequently, for airlines marginal costs are important, regarding a possible implementation of lower price limits which may be offered over a short period of time. This peculiar cost structure often leads to fierce price competition, in which, e.g. airlines are selling their seats close to variable costs (as a marginal return to the fixed costs) (see ► Chap. 3). This structure also can lead to a fast financial problem and the need for state support in a severe downturn like the Corona Crisis.

- *Strong growth coupled with low profit margins:* The airline industry has always been characterised by strong growth numbers. In the past 50 years, global aviation has grown at an average rate of about 5% per annum. The reasons for this strong growth are the on-going industry liberalisation and the resulting opening up of new markets as well as the decreasing costs of flying. Nevertheless, growing passenger numbers are accompanied by ever decreasing margins. Doganis (2005) describes the latter as the "paradoxon" of aviation. Historically, returns in the airline business have been low and can be compared to those in commodity industries. Airlines in particular are characterised by rather low profit margins that regularly fall short of those realised at airports, caterers, aircraft manufacturers and ground service providers (Doganis, 2005). Overall, many airlines do not earn their cost of capital. However, in terms of profitability, there are high variances among airlines.

  The reasons for the low margins, particularly at airlines, can partly be found in the specific industry cost structure introduced before. A further reason is the high competition within the airline industry. Moreover, airlines often claim that their low profitability arises from a "hostile" environment in which airlines are caught in a "sandwich position" in the value chain between monopolistic or oligopolistic providers that are able to generate much higher profit margins at the expense of the airlines.
- *Dependency on external input factors and shocks:* Aviation is highly dependent on and, thus, vulnerable to external input factors. This is especially true in regard to fuel prices. At airlines, kerosene bills alone regularly sum up to approximately 25–50% depending on fuel prices of the overall costs. Sharply decreasing or increasing prices for input factors can, therefore, either foster or slow down industry growth.

Mini Case: The Impact of COVID-19

By Andreas Wittmer

COVID-19 hit the aviation industry, especially airlines, in the beginning of 2020. Within 2 months, the virus spread rapidly across the globe. As a consequence, international transport came to a halt. Many airlines had to park their planes and went through cost cutting programs and demanded financial aid from governments.

World trade decreased significantly and different organisations forecasted the economic and international trade impacts of COVID-19 (◘ Fig. 2.7).

IATA forecasted that it may take until 2024 for the global air network recover to a similar level as 2019. Eurocontrol produced air traffic scenarios for 2021 showing

2

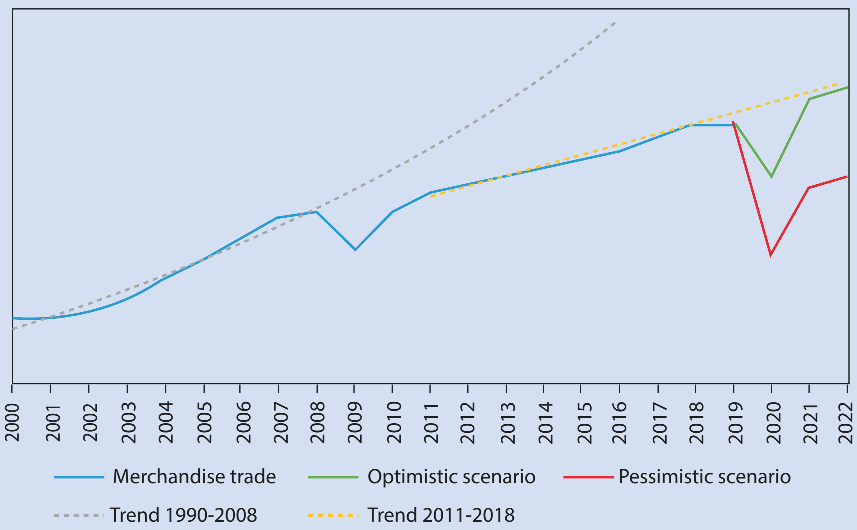


Fig. 2.7 Scenarios of world trade volume 2020–2022. (World Trade Organisation, 2020)

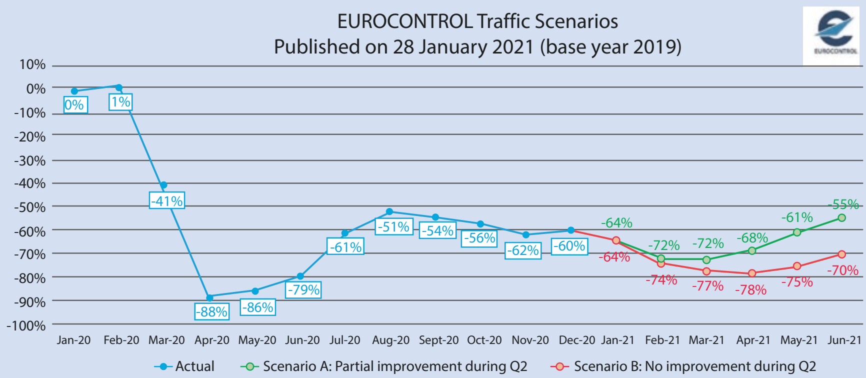


Fig. 2.8 Air traffic scenario forecasts for first half of 2021. (Eurocontrol, 2021)

less than 50% of air traffic movements for the first half of 2021 compared to 2019 (Fig. 2.8).

Governments provided financial help to airlines all around the world. Still some bankruptcies were inevitable. Especially global network airlines were struggling in contrast to regional point-to-point airlines, which were less impacted as domestic markets still had some demand for air travel.

Some governments demanded concessions from airlines in return for the financial support. It was interesting to recognise that deregulation and privatisation activities, which dominated the last decades, were suddenly overstepped by adding government control mechanisms. The German and Austrian governments, for example, took action by defining some requirements for Lufthansa and Austrian Airlines:

Lufthansa:

- Cut short-haul flights <3 h (excl. Hub connectors).
- Reduce emissions of domestic flights (inner-German) by 50% until 2024.
- Reduce CO_2 per RPK by 50% by 2030, compared to 2005 levels.
- Source 2% of fuel from sustainable sources by 2025.

Austrian Airlines:

- Cut short-haul flights <2.5 h (including hub connectors).
- Reduce emissions from domestic flights by 50% until 2030.
- Reduce total CO_2 emissions by 30% until 2030, compared to 2005 levels.
- Minimum ticket price of EUR 40.

2.6 Stakeholders in Aviation

In the aviation industry, three main groups of actors can be distinguished: the aircraft manufacturing industry, airlines and airports. These stakeholders are briefly introduced in the subsequent paragraphs.

2.6.1 Manufacturing Industry and Suppliers

The aircraft manufacturing industry is characterised by two dominant manufacturers: Boeing and Airbus. These two companies represent the main manufacturers of wide-body aircrafts. These two players as well as smaller manufacturers such as Embraer play a role for small- to medium-sized aircrafts (up to about 150 seats). Profit margins of aircraft manufacturers are commonly higher than those of airlines and airports; however, when compared to the total manufacturing industry, they are below average.

The characteristic features of the aircraft manufacturing industry are extremely high capital requirements, high entry and exit barriers, dynamic economies of scale, a high research and development (R&D) intensity and relatively long periods between initial investment and returning cash flows resulting from aircraft sales. As a consequence, prices for aircrafts must be calculated long time before the sale the aircraft on the basis of sales forecasts. Furthermore, due to dynamic economies of scale, production costs vary greatly depending on the output. Thus, an exact prediction of production levels is critical. Overall, the high investment needs, the long planning horizon and the dependence on the cyclical demand for aircraft significantly enhance the manufacturers' business risks. Launch costs for new aircraft such as the Airbus A380 or the Boeing 787 can amount to more than USD 25 billion (A380)/USD 32 billion (B787) (Wells & Wensveen, 2004). Mostly, a large part of the construction is sourced out to a network of international suppliers. While this measure aims to reduce the business risk for aircraft manufacturers, today it is considered as one of the main reasons for delays in the delivery schedule of new aircrafts (Pritchard & MacPherson, 2004). Because of the long investment cycles and the high amount of investment, the role of the state as co-owner (Airbus) or core customer (Boeing) is crucial.

Suppliers to aircraft manufacturers mainly constitute of propulsion systems manufacturers (a market dominated by General Electric, Rolls-Royce, Pratt & Whitney), equipment manufacturers (e.g. avionics, cabin, electrical and hydraulic systems) as well as commodity suppliers (e.g. metallic and composite assemblies). Nowadays, up to 70 percent of the added value of aircrafts may stem from the supplying industry (Pritchard & MacPherson, 2004).

2.6.2 Airlines

In the aviation industry, airlines represent the most visible group of actors. Even though every airline offers the same core service (the transport of passengers or cargo from one destination to another), by no means the group of airlines is a homogeneous one. Between airlines, fundamental differences exist in regard to the underlying business model, i.e. the service level offered, the regional reach and the main functions.

The business model of the *international full-service network carriers* or *flag carriers* is largely based upon the operation of a hub-and-spoke network with a strong focus on transfer traffic. By carefully synchronizing inbound and outbound flights, passengers can optimally transfer and connect to different flights at an airport hub and by this has the opportunity to reach a greater number of destinations. Direct services between the major cities (mainly national) complement the network. In the main international traffic regions, important international network carriers can be found, for example, in North America (carriers such as Delta Airlines, American Airlines or United Airlines), in Europe (e.g. Air France-KLM, Lufthansa and British Airways), and in the Asia/Oceania region (e.g. Emirates, Singapore Airlines and Qantas Airways). As the main source of revenues in this group of airlines is the actual transport fare, the majority of traditional airlines still offer all-inclusive prices (including return flights, luggage handling, etc.). However, traditional airlines have shifted towards one-way basic fares with less frills due to the advent of low-cost carriers. They unbundled especially their short-haul flights and offer different price-based packages with more or less services included and by this offer a basic transport option where services have to be extra paid for, like point-to-point low-cost airlines do. On the long-haul flights full-service network carriers offer a highly service-intensive product. On the one hand, this allows them to attract business traffic and to realise a price premium. On the other hand, it leads to highly complex and expensive network designs and operational structures.

Network niche carriers represent a modification of the traditional network carriers. Due to their smaller size, network niche carriers merely operate regional networks with a few connections to major international hubs (e.g. SAS, Austrian Airlines, SWISS). Often, niche carriers are a subsidiary of the so-called "mega-carriers" such as Lufthansa or Air France/KLM and operate partly as wet lease operations for them.

Smaller *regional carriers* (e.g. Helvetic) pursue a different business model. They focus on linking remote areas with thin flows or on feeding into the hubs of network carriers often in wet lease contracts.

Further relevant business models are the point-to-point low-cost carriers (e.g. Southwest, Ryanair, easyJet, AirAsia) and charter airlines (e.g. TUIfly). In contrast to traditional network carriers, *low-cost carriers* (LCC) concentrate on a high volume short- to medium-haul point-to-point traffic based on a minimum service approach ("no frills") and lean operations (no seat reservation; no frequent flyer programs, narrow seating). The carriers either use smaller (and cheaper) secondary airports (e.g. Ryanair) or fly into major airports and thus, directly compete with established airlines (e.g. easyJet). LCCs heavily rely on ancillary revenues, which are generated, for example, from offered catering as well as from luggage fees. Ancillary revenues can make half of the carriers' revenues (*Financial Times* 19.9.2017). LCCs usually pursue unbundled pricing strategies which are in contrast to the ones pursued by traditional carriers.

Charter airlines service tourist markets. Their strategy is a combination of service quality, low-cost structures and their integration of the passengers' travel chain. However, charter airlines are more and more substituted by low-cost carriers on highly frequented traffic routes (e.g. from the United Kingdom to Southern Spain).

Air cargo carriers are a special form of an airline business model. The network carriers introduced above generally have their own cargo fleets (e.g. Korean Cargo, Lufthansa Cargo) whereas in the field of air cargo carriers, some airfreight-only carriers exist (e.g. FedEx, Polar Air, Cargolux). These companies ship cargo in their freighters as well as in the cargo compartments of their passenger fleet (belly freight).

2.6.3 Air Taxi Services

In the United States, air taxi services have been existing for many years and they are growing remarkably in the European market. Operators like NetJets are at service for individual travellers and companies who prefer to travel on business jets. They operate partly as feeders to mega-carriers regarding first class passengers. The saving of travel time and the direct reachability of all regions in the world are some of their main advantages. By means of significantly lower air fares, new very light jets (VLJ) are supposed to change the air taxi business. In the business jet service, there also exist network effects (e.g. NetJets). Bigger providers operating more jets can offer more flexibility and, thanks to better average usage of their jets, lower rates.

2.6.4 Airports

Airlines are dependent on airports, which are providers of ground infrastructure (e.g. runways and terminals). Airports have an extremely high specificity of their infrastructure investment. A large number of national and international airports still are under public ownership; noteworthy privatisation trends have only recently been observed and ownership and operation are often separated. In many cases the concession to operate the airport does not belong to the owner of the airport, but rather to the operator. There are different airport ownership structures such as state-owned airports, public private partnerships, privately owned airports, international airport groups, etc.

Airports are not a homogeneous group. Among others they differ in their size, function and regional reach. Airports like Chicago O'Hare, London Heathrow or Singapore Changi are international hubs ("mega hubs"). They concentrate on intra-regional and international transport and serve as starting and end point for intercontinental long-haul services. Secondary airports focus on intra-regional services (e.g. intra-European or intra-American air transportation). Regional airports, which habitually are only served by smaller aircrafts, focus on feeder flights to international or national hubs. Overall, there is a high degree of concentration among passenger flows at airports, for example, in North America 72 percent of all passenger enplanements are accounted for by 30 hubs (FAA, 2018). Furthermore, the highest growth in traffic flows in the two upcoming decades will be between so-called aviation mega-cities (AMC), where most aviation connectivity/international passengers can be found, as well as between AMC and secondary airports (Airbus, 2019). In numerical terms, small airfields represent the largest group of all airports. Small airfields serve general aviation like private business aviation and leisure/sports flying.

Airports pursue different business models that depend on their sizes, functions and locations. Particularly at major international airports, traditional revenue sources, e.g. landing fees, merely represent a small part of all income sources. Non-aviation income sources, such as parking and real estate, often represent more than half of the total revenues. Usually, the service level provided at these airports (e.g. infrastructure connections to other modes of transportation, lounges) is relatively high. Airports that mainly serve low-cost airlines, however, only provide a minimum of services. Due to their remote locations, ground infrastructure connections are usually poor. In contrast to the group of airports introduced above, these airports often generate losses and thus operate at the taxpayers' expenses.

2.7 Main Drivers and Economies

The potential market of airlines depends on the extent of economic growth and the internationalisation of economies. Furthermore, a country's regulation and international global regulation create boundaries of the air transport market. Technical developments have a great impact on cost structures of airlines and air transport companies which, in turn, influence the air transport market. The most important economies in the air transport market are presented in the following paragraphs.

Economies of Technology

- New planes have lower costs per available seat/km (CASK) (e.g. Airbus A350).
- Smaller planes are able to fly longer distances (e.g. Boeing 787).
- New engines with lower fuel consumption and carbon-neutral fuel as perspective.

Economies of Scale

- Bigger planes have lower costs of available seat/km (CASK) (e.g. Airbus A380).
- Bigger airports are cheaper per passenger.

Economies of Scope

- Bigger airlines provide more origin and destinations with comparably fewer legs (e.g. alliances like Star Alliance).

Economies of Density

- Airlines dominating hubs show comparably higher market shares.

Further Economies of Networks

- Airports have two sided markets (airline customers and passengers; aviation and non-aviation market).
- Network effects of the hub business model (scale, scope and density effects).

2.8 Approach Towards an Integrated Aviation System

The aviation system can be seen in a framework where social, economic, technological, ecological and political factors create an integrated system, the aviation system. The social and political systems profit from aviation. Moreover, they profit from the opportunity to getting to know new cultures and, thus, to create a mutual understanding between cultures. However, there are negative factors as well, such as safety and security and noise emission, which are perceived by the society. The economic system deals with demand and supply in the air transport market. A demand growth contributes to the growth of direct economic factors like jobs and revenues of air transport companies but also indirect and induced economic factors along the supply chain. Furthermore, catalytic effects such as accessibility (e.g. for international companies or tourism) play an important role for a country's international attractivity compared to other countries. On the other side, factor cost and the absorption of resources are compared to positive economic effects in the economic system. The technological system focuses on a better performance of, for example, engines and aerodynamics. New innovations that help the aviation industry to perform more economically and ecologically are of great importance in the technology system. Technology puts pressure on aviation operators to reinvest in new innovation in order to become more efficient in the market. Safety and security also play a very important role in the technology system. The environmental system mainly deals with natural resources and the fact that resources are for free (e.g. oxygen, CO_2 emissions, airspace, etc.). The natural environment is mainly

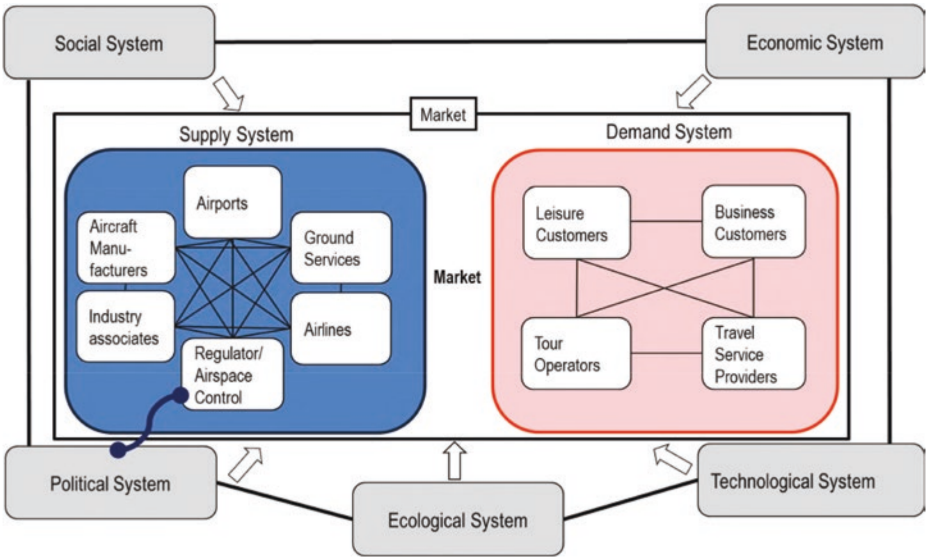


Fig. 2.9 The aviation system. (Author's own figure)

impacted by gas emissions (to a great extent CO_2), volatile organic compounds and microparticles (dust) and noise. The development of sensitivity for natural beauty and on the negative side pollution in high altitude and pollution at airports are dealt with in the environmental system.

In summary, this system represents the framework in which the air transport companies and organisations operate. The core system consists of a supply system and a demand system. The supply system consists of all partners along the supply chain that deliver to airlines and airports and the surrounding ecosystem. On the demand side, there are consumers, like leisure and business customers, tour operators and travel sources that pay for an air service. Airlines generate their revenues from the market. The whole supply system is being paid from these revenues, e.g. airport taxes are collected by airlines. By this the airlines are the most important factor in the supply system, in the aviation market and for whole aviation system. Figure 2.9 illustrates the aviation system.

In the following chapter, the aviation system will be looked at in detail.

Review Questions

- Who are the main players in the aviation industry value chain?
- Who are the main stakeholders of the aviation industry?
- What are the special characteristics of air transportation?
- How are economic development and the aviation industry linked?
- What is the problem of industries with high fixed costs?
- What are the economies of technology of airlines?
- What are the economies of scale of airlines?
- What are the economies of scope of airlines?
- What are the economies of density of airports?
- What are the environments of the aviation system?

Literature

Airports Council International [ACI]. (2019). *International traffic report 2017*. Author.

Airbus. (2019). *Global market forecast 2019–2038*. Toulouse: Author.

ATAG. (2020). *Aviation: Benefits beyond borders*. Author. Retrieved from https://aviationbenefits.org/media/167186/abbb2020_full.pdf

Baltagi, B. H., Griffin, J. M., & Rich, D. P. (1995). Airline deregulation: The cost pieces of the puzzle. *International Economic Review, 36*(1).

Baumol, W. J., Panzar, J. C., & Willig, R. D. (1982). *Contestable markets and the theory of industry structure*. Jovanovich.

Becker, B., & Dill, N. (2007). Managing the complexity of air cargo revenue management. *Journal of Revenue and Pricing Management, 6*(3), 175–187.

Benkenstein, M., Bruhn, M., Büttgen, M., Hipp, C., Matzner, M., & Nerdinger, F. W. (2017). Topics for service management research-a European perspective. *SMR-Journal of Service Management Research, 1*(1), 4–21.

Button, K. J. (1996). Aviation deregulation in the European Union: Do actors learn in the regulation game? *Contemporary Economic Policy, 1*.

Card, D. E. (1996). *Deregulation and labour earnings in the airline industry*. National Bureau of Economic Research.

Dempsey, P. S., & Goek, A. R. (1992). *Airline Deregulation and Laissez-Faire Mythology*. Westport: Conn.

Doganis, R. (2005). *Flying off course. The economics of international airlines* (2nd ed.). Routledge.

easyJet. (2019). Annual report and accounts. Luton: Author. Retrieved from http://corporate.easyjet.com/~/media/Files/E/Easyjet/pdf/investors/results-centre/2019/eas040-annual-report-2019-web.pdf.

Eccles, R. G., & Klimenko, S. (2019). The investor revolution. *Harvard Business Review. 5, 106–116*.

Eurocontrol. (2021, January 28). *New EUROCONTROL traffic scenarios factor in latest COVID impacts on European aviation* [Press release]. Retrieved 4 March 2021, from https://www.eurocontrol.int/traffic-scenario/new-eurocontrol-traffic-scenarios-factor-latest-covid-impacts-european-aviation

Federal Aviation Administration [FAA]. (2018). *National plan of integrated airport systems (NPIAS)*. Washington, DC: Author.

Flightglobal. (2017). *World airline rankings 2016*. Sutton: Author.

Flightglobal. (2018). *World airline rankings 2017*. Sutton: Author.

Grundmann, S. (1998). *Marktöffnung im Luftverkehr*. Nomos.

Heitmann, V. (2005). *Airline performance management*. Gutenberg.

History of aviation. (n.d.). In *Wikipedia*. Retrieved 13 March 2021, from https://en.wikipedia.org/wiki/History_of_aviation

Huse, C., & Evangelho, F. (2007). Investigating business traveller heterogeneity: Low-cost vs. full-service airline users? *Transportation Research Part E, 43*(3), 259–268.

IATA. (2019). *World air transport statistics*. Author.

International Energy Agency. (2020). *Aviation*. Author. Retrieved from https://www.iea.org/reports/aviation

Kahn, A. E. (1988). Surprises of airline deregulation. *American Economic Review, 78*(2), 316–322.

Kaminski-Morrow, D. (2019, February 7). *EasyJet confident over post-Brexit preparations: chairman | News*. Retrieved from Flight Global: https://www.flightglobal.com/strategy/easyjet-confident-over-post-brexit-preparations-chairman/131291.article.

Kennet, D. M. (1993). Did deregulation affect aircraft engine maintenance? An empirical policy analysis. *The Rand Journal of Economics*, *4*.

KPMG. (2016). Brexit: implications for airlines. London: Author. Retrieved from https://assets.kpmg/content/dam/kpmg/cl/pdf/2016-11-kpmg-chile-advisory-brexit-airlines.pdf.

Larsen, P. B., Sweeney, J. C., & Gillick, J. E. (2006). *Aviation law: Cases, laws and related sources*. Transnational Publishers.

Littorin, H. (2015). Catalytic effects of aviation and their importance for airport development. *Journal of Airport Management, 9*(4), 384–389.

Mack, O., Khare, A., Krämer, A., & Burgartz, T. (Eds.). (2015). *Managing in a VUCA world*. Springer International Publishing Switzerland 2016.

Martinez, L. M., Turnbull, P. J., Blyton, P. & McGurk, J. (2001). Using Regulation: An International Comparative Study of the Civil Aviation Industry in Britain and Spain. *European Journal of Industrial Relations, 7*(1), 49–70.

Morrison, S. A., & Winston, C. (1997). *The evolution of the airline industry*. The Brookings Institution.

O'Reilly, D. (1995). Classical competitive strategy in newly deregulated industries – Does it apply? In *International review of strategic management*. John Wiley.

O'Reilly, D., & Stone Sweet, A. (1998). The liberalization and reregulation of air transport. *Journal of European Public Policy, 5*(3), 447–466.

Planète Energies. (2019). *Fuels in aviation and shipping*. https://www.planete-energies.com/en/medias/close/fuels-aviation-and-shipping

Pompl, W. (2007). *Luftverkehr: Eine ökonomische und politische Einführung* (5. Aufl.). Berlin: Springer.

Pritchard, D., & MacPherson, A. (2004). Industrial subsidies and the politics of world trade: The case of the Boeing 7e7. *The Industrial Geographer, 1*(2), 57–73.

Rencher, R. J. (2019). *Progressive Disintermediation of the Commercial Aviation Industry Ecosystem* (No. 2019-01-1330). SAE Technical Paper.

Schäfer, I. S. (2003). *Strategische Allianzen und Wettbewerb im Luftverkehr*. Mensch-und-Buch Verlag.

Schroeder, U. (2002). Swissair 1931–2002. Aufstieg, Glanz und Ende einer Airline. Frauenfeld. Huber &

Shepherd, B., Shingal, A., & Raj, A. (2016). *Value of air cargo: air transport and global value chains*. Montreal: IATA.

Spiegel Online. (2007, April 30). *USA und Europa öffnen Airlines den Himmel*. available at: www.spiegel.de.

Sterzenbach, R. & Conrady, R. (2003). *Luftverkehr: betriebswirtschaftliches Lehr- und Handbuch*. München: Oldenbourg Verlag.

Swedenborg, E. (1716). *Sketch of a Machine for Flying in the Air, Periodicals of Swedenborg*. available at: http://en.wikipedia.org/wiki/Flying_Machine_%28Swedenborg%29.

Wells, A. T., & Wensveen, J. G. (2004). *Air transportation. A management perspective* (5th ed.). Brooks/Cole Publishing.

Wenglorz, G. W. (1992). *Die Deregulierung des Linienluftverkehrs im Europäischen Binnenmarkt*. Decker's Verlag Schenck.

World Trade Organisation. (2020, May 8). *Trade set to plunge as COVID-19 pandemic upends global economy* [Press release]. Retrieved 4 March 2021, from https://www.wto.org/english/news_e/pres20_e/pr855_e.htm