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Introduction and Overview

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This chapter presents a brief introduction to the global airline industry, its evolution and current status. The major forces shaping the industry are described, including deregulation and liberalization worldwide, along with some important recent industry challenges, such as the severe financial problems and restructuring of some of the industry's largest airlines since 2000. In 2015, the global airline industry is approaching six consecutive years of aggregate profitability for the first time since the late 1990s, although there remain large differences in financial performance among airlines in different regions of the world. The industry still faces major challenges, including historically high and volatile fuel prices, a weak economic recovery from the global financial crisis, and a variety of geopolitical and public health threats that could soon end this streak of moderate profitability. Infrastructure capacity poses a major constraint worldwide and threatens continued evolution and long-term profitability. The final section provides a brief overview of Chapters 2–17.

1.1 Introduction: The Global Airline Industry

The global airline industry provides service to virtually every country in the world, and has played an integral role in the creation of a global economy. The airline industry itself is a major economic force, in terms of both its own operations and its impacts on related industries such as aircraft manufacturing and tourism, to name but two. Few other industries generate the amount and intensity of attention given to airlines, not only by those directly engaged in its operations but also by government policy makers, the news media, as well as its billions of users, who almost to a person have an anecdote to relate about an unusual, good or bad, air travel experience.

During much of its development, the growth of the global airline industry was enabled by major technological innovations such as the introduction of jet airplanes for commercial use in the 1950s, followed by the development of wide-body “jumbo jets” in the 1970s. At the same time, airlines were heavily regulated throughout the world, creating an environment in which technological advances and government policy took precedence over profitability and efforts to

promote competition in the industry. It has only been in the period since the economic deregulation of airlines, beginning with the United States in 1978, that cost efficiency, operating profitability, and competitive behavior have become the dominant issues facing airline management. Airline deregulation or, at least, “liberalization” has now spread far beyond the United States to most of the industrialized world, affecting both domestic air travel within each country and, perhaps more importantly, the continuing evolution of a highly competitive international airline industry.

Today, the global airline industry consists of over 1400 commercial airlines operating more than 25 000 commercial aircraft and providing service to over 3800 airports (ATAG, 2014). In 2013, the world’s airlines flew more than 36 million commercial flights and transported roughly 3.1 billion passengers (IATA, 2014a). The growth of world air travel has averaged approximately 5% per year over the past 30 years, with substantial yearly variations due to both changing economic conditions and differences in economic growth in different regions of the world. Historically, the annual growth in air travel has been about twice the annual growth in gross domestic product (GDP), although this relationship has been weakening in advanced economies in recent years. Even under relatively conservative assumptions concerning economic growth over the next 10–15 years, a continued 4–5% annual growth in global air travel will lead to a doubling of total air travel during this period.

The annual growth rates in passenger air traffic, measured in revenue passenger kilometers (RPKs) (see Chapter 3 for definitions), are shown in greater detail in Figure 1.1, for the period 1984–2013. The principal driver of air travel demand is economic growth: over the period shown in Figure 1.1, the 5–6% average annual growth in air travel has been fed by an average 2–3% annual GDP growth worldwide. However, there has been substantial variability from year to year, as well as differences between US and non-US airlines. World passenger air traffic growth has been positive in all years shown, with only three exceptions. Traffic declined in

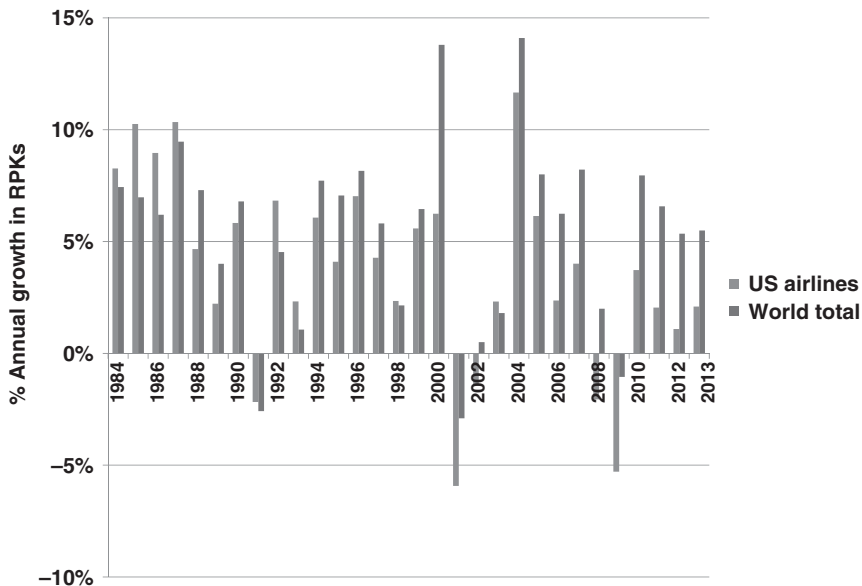


Figure 1.1 Annual RPK growth rates 1984–2013. (Data sources: Air Transport Association; ICAO)

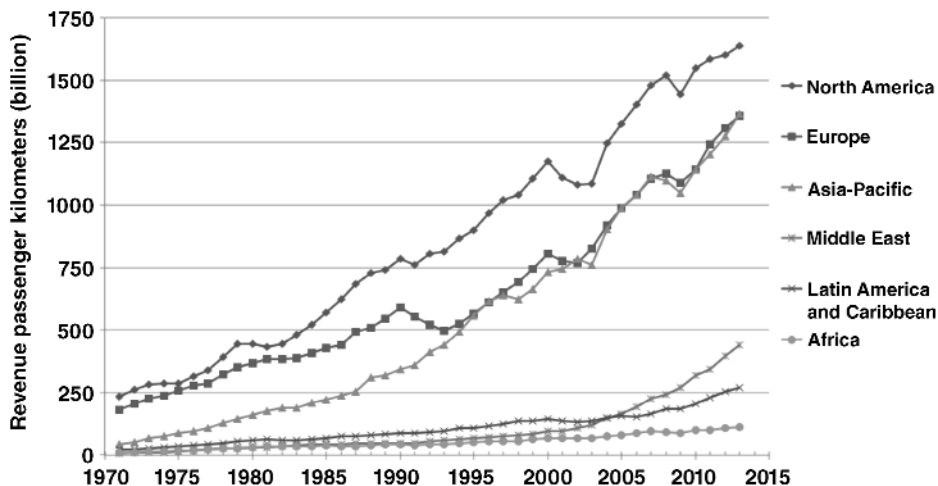


Figure 1.2 Growth of airline passenger traffic by world region. (Data sources: ICAO, 1971–2005; IATA, 2006–2013)

1991 due to the first Gulf War and the subsequent fuel crisis and economic recession, in 2001 due to the effects of the 9/11 terror attacks in the United States, and then again in 2009 during the global financial crisis. Figure 1.1 also shows that the annual growth rates experienced by non-US airlines have consistently outpaced those of US carriers. As a result, the proportion of world passenger traffic carried by US airlines has declined, from approximately 40% in the mid-1980s to less than 25% in 2013.

The growth of passenger air traffic by region of the world carried by all airlines (irrespective of their nationality) is illustrated in Figure 1.2. North America continues to represent the largest region in terms of air traffic, followed by Europe and Asia-Pacific. North American air travel was clearly the most affected by the terror attacks of 9/11, whereas traffic dropped in all three of the largest regions during the global financial crisis in 2009. Growth rates in the Asia-Pacific region during the 1980s and 1990s were substantially higher than those of North America and Europe, with the result that total passenger air traffic in the Asia-Pacific region has been at about the same level as in Europe for much of the time since 2005. With continued high growth rates expected, the Asia-Pacific region could soon become the second-largest world region for air traffic.

Figure 1.3 provides a similar plot of the growth of air freight by world region since 1971, measured in freight tonne kilometers (FTKs) – defined in Chapter 3. The relative size and growth of air freight in each world region differs from that of passenger air traffic, with Europe generating slightly more air freight than North America in the first part of the period shown in Figure 1.3. However, the growth of air freight in the Asia-Pacific region has surged over the past three decades and the region has led the world in terms of total air freight volume since 1992. The impacts of the global financial crisis on air freight were more dramatic than was the case for passenger traffic. After a partial recovery in 2010, air freight volumes have stagnated in North America and Europe, and have declined in the Asia-Pacific region. In contrast, they have increased consistently in the Middle East region. As shown in Figures 1.2 and 1.3, the Middle East has experienced rapid growth in both categories since 2000.

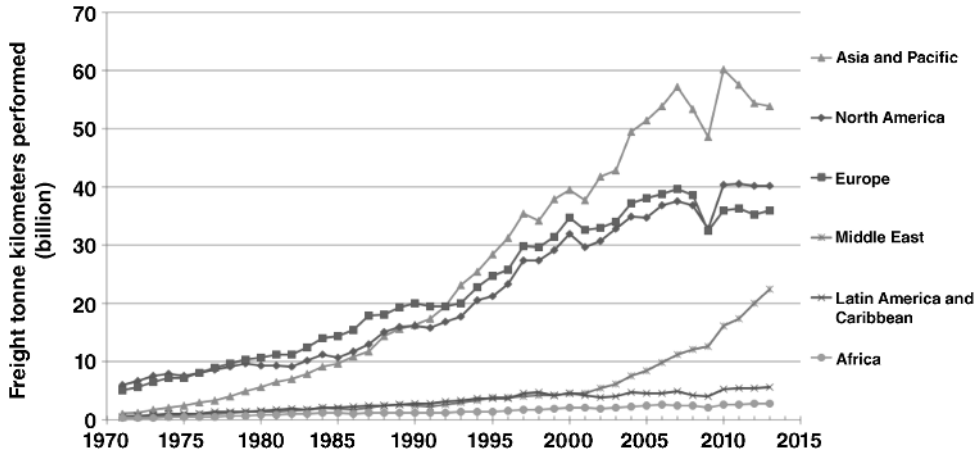


Figure 1.3 Growth of air freight volumes by world region. (Data sources: ICAO, 1971–2005; IATA, 2006–2013)

In the US airline industry, approximately 70 certificated passenger airlines operate close to 10 million flight departures per year, and carry approximately one-quarter of the world's total air passengers – US airlines enplaned 743 million passengers in 2013. US airlines (both cargo and passenger) reported \$200 billion in total operating revenues, with approximately 580 000 employees and 6700 aircraft operating over 25 000 flights per day (Airlines for America, 2014a). The economic impacts of the airline industry range from its direct effects on airline employment, company profitability, and net worth to the less direct but very important effects on the aircraft manufacturing industry, airports, and tourism, not to mention the economic impact on virtually every other activity that the ability to travel by air generates.

Commercial aviation contributes 5% of the US GDP, according to recent estimates (Airlines for America, 2014a). Worldwide, the global economic impact of aviation has been estimated to be about 3.4% of world GDP or more than US\$2.4 trillion in 2012 (ATAG, 2014). These estimates include direct, indirect, induced, and catalytic economic impacts, but do not include additional economic benefits such as employment or business activity made possible by air transportation.

The economic importance of the airline industry, and, in turn, its repercussions on so many other major industries, makes the volatility of airline profits and their dependence on good economic conditions a serious national and international concern. As shown in Figure 1.4, the total net profits of world airlines have been cyclical and extremely variable since the start of deregulation in 1978. After the world airline industry posted four consecutive years of losses totaling over \$22 billion from 1990 to 1993, as a result of the Gulf War and subsequent economic recession, it returned to record profitability in the late 1990s. Even more dramatic were the industry's plunges into record losses between 2001 and 2005, and then again in 2008–2009. The string of profitable years since 2010 gives the industry its first period of sustained profitability since the late 1990s.

1.1.1 Deregulation and Liberalization Worldwide

Since the deregulation of US airlines in 1978, the pressure on governments to reduce their involvement in the economic regulation of airlines has spread to most of the rest of the world.

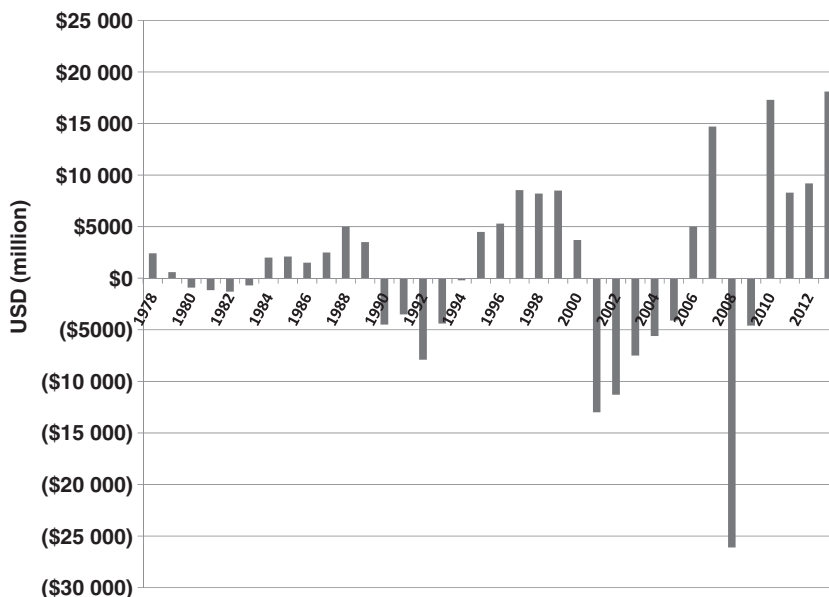


Figure 1.4 World airline net profits 1978–2013. (Data sources: Airlines for America; ICAO)

US airline deregulation is perceived as a success by most other countries, as the overall benefits to the vast majority of air travelers have been clearly demonstrated. While US domestic air travel grew at rates significantly greater than prior to deregulation, average real fares have declined significantly since deregulation and in 2013 were 40% below 1978 levels in constant prices (Airlines for America, 2014b). Successful new entrant and low-fare airlines had a great impact both on airline pricing practices and on the public's expectations of low-priced air travel. And, despite worries at the time of deregulation that competitive cost pressures might lead to reduced maintenance standards, there has been no statistical evidence that airline safety has deteriorated (Chapter 12).

At the same time, deregulation in the United States has had some negative impacts. The pressure to cut costs, combined with increased profit volatility, mergers, and bankruptcies of several large airlines, led to periodic job losses and reduced wages. Furthermore, the benefits of deregulation have not been enjoyed equally by all travelers. Residents of some small US cities saw changes in the pattern of air service to their communities, as smaller regional airlines replaced previously subsidized jet services. And, despite a substantial decrease in the average real fare paid for air travel in US domestic markets, the disparity between the lowest and highest fares offered by airlines increased, thus forcing business travelers to pay the higher fares. The development of large connecting hubs by virtually all US major airlines also raised concerns about the pricing power of dominant airlines at their hub cities (GAO, 1993).

The management strategies and practices of airlines were also fundamentally changed by increased competition within the industry. Cost management and productivity improvements became central goals of US airlines with the shift to market competition. Non-US airlines have more recently been forced by competitive realities to face this challenge as well. A by-product of the quest for lower costs and increased productivity has been the pursuit of economies of

scale by both US and non-US airlines. In the past, internal growth and/or mergers were the primary ways in which airlines hoped to take advantage of scale economies. With growing government concerns about industry consolidation, further mergers began to receive greater regulatory scrutiny. And, with regulations limiting foreign ownership of airlines still enforced by many countries (Chapter 2), complete mergers between airlines of different countries continue to face legal barriers. The response of airlines has been to expand their networks and to achieve at least some economies of scale through partnerships and “global alliances” designed to offer a standardized set of products and to project a unified marketing image to consumers.

1.1.2 Industry Evolution Since 2000

Globally and especially in the United States, the airline industry faced serious financial challenges for much of the first decade of the twenty-first century. The problems that began with the economic downturn at the beginning of 2001 reached almost catastrophic proportions after the terror attacks of September 11, 2001. In the United States alone, the industry posted cumulative net losses of over \$40 billion from 2001 to 2005, and only in 2006 was it able to return to profitability with a total net profit of just over \$3 billion (Heimlich, 2007). Many of the same forces affected non-US airlines, which as a group recorded losses in 2001–2003, but posted modest net profits in 2004 and 2005. Airlines outside the United States were particularly affected by international military and political events, as well as the SARS-related health crisis in 2003.

Airlines were in serious trouble even before the events of 9/11, as the start of an economic downturn had already affected negatively the volume of business travel and average fares. At the same time, airline labor costs and fuel prices had been increasing faster than the general rate of inflation for several years. To make matters worse, airlines faced deteriorating labor–management relations, aviation infrastructure constraints that led to increasing congestion and flight delays, and dissatisfied customers due to perceptions of poor service.

As shown in Figure 1.5, the proportion of available seats filled with revenue passengers (i.e., the load factor) has increased steadily since the mid-1990s for both US and world airlines, with particularly dramatic increases since 2001. By 2013, the average load factor for US airlines reached 83%, more than 10 percentage points higher than in 2000. At the same time, world airlines as a group saw their load factors increase to almost 80%, an unprecedented level that might imply significant financial success. However, despite operating flights that were becoming increasingly full, many traditional or “legacy” airlines around the world still struggled to make an operating profit given that much of the increase in the proportion of seats sold stemmed from fare discounting in the face of increasing competition.

1.1.2.1 Impact of Low-Cost Carriers Worldwide

The rapid growth of “low-cost carriers” (LCCs) offering low-fare air travel options contributed in a major way to the poor financial performance of traditional airlines, both in the United States and in many other countries. The low-cost carrier concept, born in the United States prior to deregulation, has now taken root in many other parts of the world where LCCs have grown even more rapidly. Figure 1.6 shows the 25 largest LCCs in the world as of 2013, ranked by number of passengers carried. Low-cost pioneer Southwest Airlines (the United States) remains by far the largest LCC, followed by European LCCs Ryanair and easyJet. The

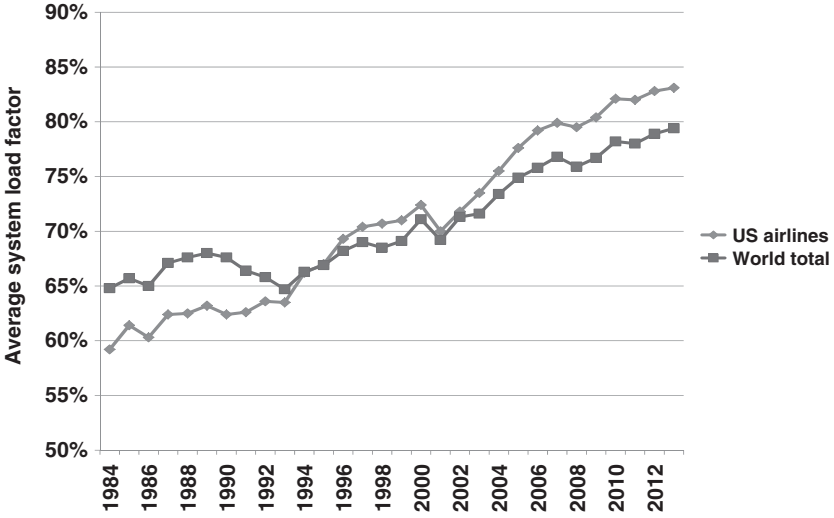


Figure 1.5 US and world airline passenger load factors 1984–2013. (Data sources: Airlines for America; ICAO)

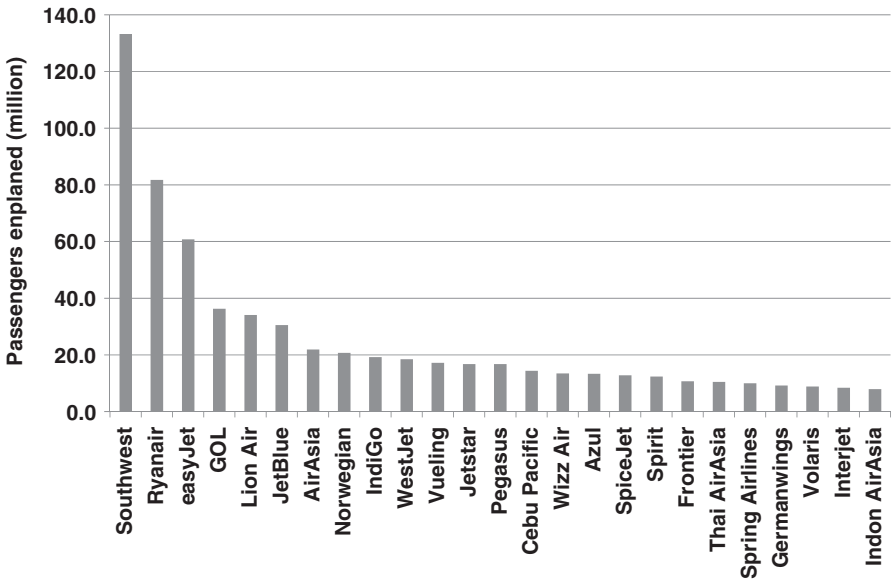


Figure 1.6 Largest low-cost carriers (LCCs) ranked by passengers enplaned 2013. (Data source: Airline Business, 2014)

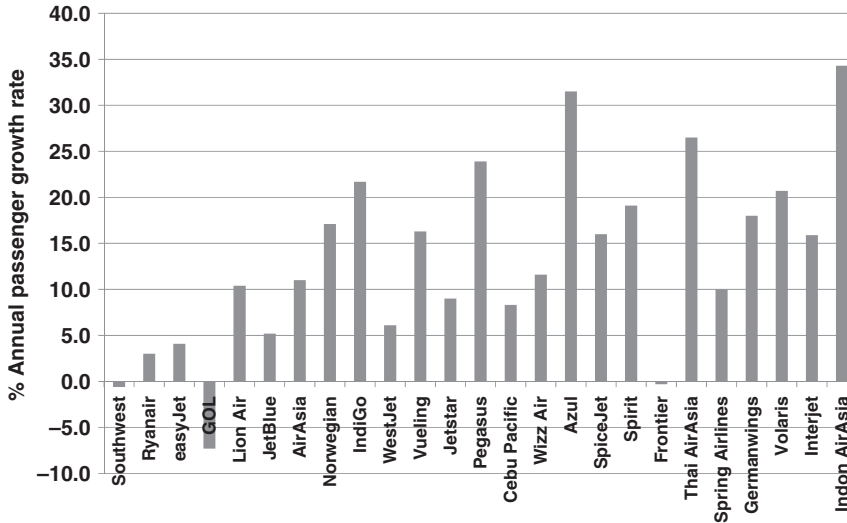


Figure 1.7 Annual growth percent in passengers carried for largest LCCs 2012–2013. (*Data source:* Airline Business, 2014)

presence of LCCs from other regions of the world in the top 10 illustrates the extent to which the LCC concept has spread – GOL operates in South America, Lion Air and AirAsia are based in Southeast Asia, and IndiGo serves India. However, despite their impacts on pricing in the markets where they compete with other airlines, most of the largest LCCs shown remain relatively small, compared to the largest international network airlines.

However, the growth rates of the smaller LCCs around the globe continue to be impressive. As shown in Figure 1.7, while the largest and most established LCCs exhibited little or no passenger growth in 2013, virtually all of the remaining LCCs grew at rates of well over 10% per year. And, led by Indonesian AirAsia and Azul (Brazil) with astounding growth of more than 30%, 12 of the LCCs shown achieved annual growth rates greater than 15% in a year in which the global airline industry traffic growth averaged 5.7% (IATA, 2014b).

The LCCs thus continue to change the competitive landscape in regions with liberalized airline markets, affecting pricing structures with their substantially lower fares and, in turn, the revenues of traditional legacy airlines that are effectively forced to match these lower prices to remain competitive. In addition to creating a serious revenue problem for legacy airlines, the emergence of LCCs as a formidable competitive force made it clear that legacy airlines had fundamental operating cost and productivity disadvantages compared to their low-cost challengers.

The differences in the cost structures between legacy airlines and low-cost carriers reflected substantial differences in the productivity of both aircraft and employees. Low-cost carriers tend to operate in a “point-to-point” manner in which they can minimize aircraft ground times, in contrast to the hub-and-spoke networks of the largest legacy airlines. Shorter ground times translate directly into higher aircraft utilization rates. As a result, LCCs in the United States were able to achieve aircraft utilization rates more than 45% higher than what legacy carriers achieved for the same aircraft type, which contributed 35% lower to unit aircraft operating costs (US DOT, 2007).

Perhaps the most critical element of the successful low-cost airline business model is significantly higher labor productivity than that of traditional legacy carriers. The differences can be attributed to labor productivity *per se*, not simply to employee unionization nor even to wage rates. The oldest LCC in the United States, Southwest Airlines, is the most heavily unionized US airline, and its salary rates are considered to be at or above average compared to the industry. The low-cost carrier labor advantage lies in much more flexible work rules that allow cross-utilization of virtually all employees (except where disallowed by licensing and safety standards). These strategies, used for several decades by Southwest Airlines to increase both labor and aircraft productivity, have now been replicated in some respects by virtually every new entrant LCC in every world region.

The challenges described above led four out of the six US legacy carriers (US Airways, United, Delta, and Northwest) (Chapter 11) to bankruptcy between 2001 and 2005. Under bankruptcy protection, these carriers were able to focus on downsizing, cutting operating costs, and improving productivity as part of their restructuring efforts. Much of the cost-cutting strategy focused on labor: Legacy airline employment was reduced by 30% in just 5 years, representing over 100 000 jobs lost while average wage rates were also cut by 7% (US DOT, 2007).

Non-US airlines were not immune to bankruptcies and even to liquidation during the same period. Financial problems forced Swissair to cease operations and restructure itself under new ownership as Swiss International Airlines. In the process, employees lost jobs, aircraft were removed from its fleet, and routes were eliminated. Belgian flag carrier Sabena shut down its operations after it was unable to restructure. Air Canada, after merging with Canada's other flag carrier, Canadian Airlines International, declared bankruptcy in 2003, but has since restructured its costs and business model to return to profitability. Ansett Airlines of Australia was liquidated in 2002; in South America, notable legacy airlines such as Varig and Aerolineas Argentina experienced bankruptcies.

In response to these challenges and in an effort to restructure, legacy airlines in many regions of the world achieved productivity gains by introducing new technologies (e.g., Internet ticket distribution and web check-in) and by reallocating capacity (e.g., moving capacity from domestic to international routes in an effort to improve aircraft utilization with increased stage lengths). Some of these carriers have also attempted to imitate strategies of the low-cost carriers, for example, by eliminating meals on shorter flights to reduce costs and by reducing aircraft turnaround times to improve aircraft productivity.

Many LCCs were able to expand their networks rapidly and captured significant market share, not only in the United States but also in Europe, Canada, and South America. They expanded into new markets with new aircraft, more flights, and, of course, lower fares. However, as they matured, some of the more established LCCs also began to face increasing operating costs, driven by aging fleets and personnel with increasing seniority. In addition, the LCCs could not escape the impacts of increasing fuel costs – even the successful fuel hedging strategy of Southwest provided only a temporary reprieve. In fact, the concerted cost-cutting efforts of both legacy airlines and LCCs were not sufficient to offset the increased fuel prices, which quadrupled between 2000 and 2008 (Figure 1.8). After a temporary drop, fuel prices increased again with the post-recession economic recovery and remained above \$120 per barrel for several years, at a level three times that of 2000.

The growth of LCCs during the past decade has affected most world regions, as shown in Figure 1.9. Between 2004 and 2013, LCCs increased their shares of capacity (available seat

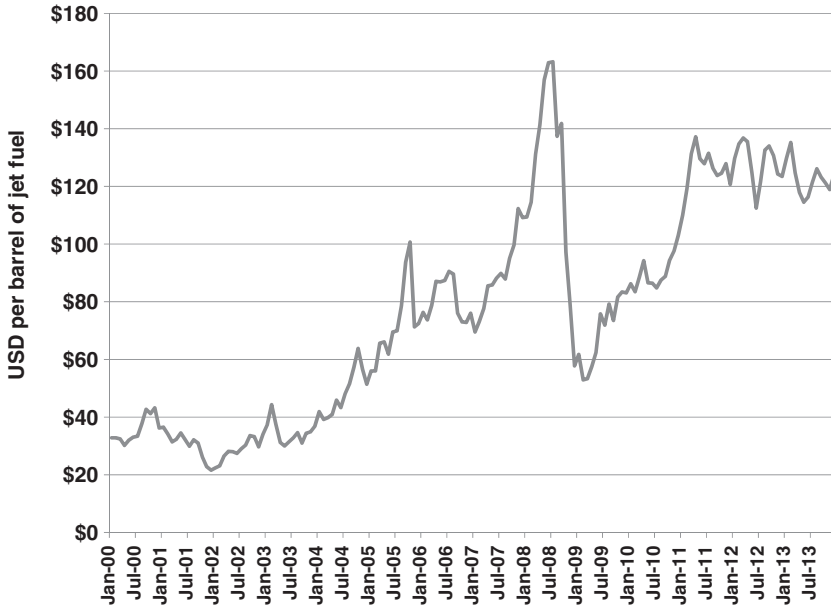


Figure 1.8 US airline jet fuel prices (current dollars) 2000–2013. (Data source: Airlines for America, 2014a)

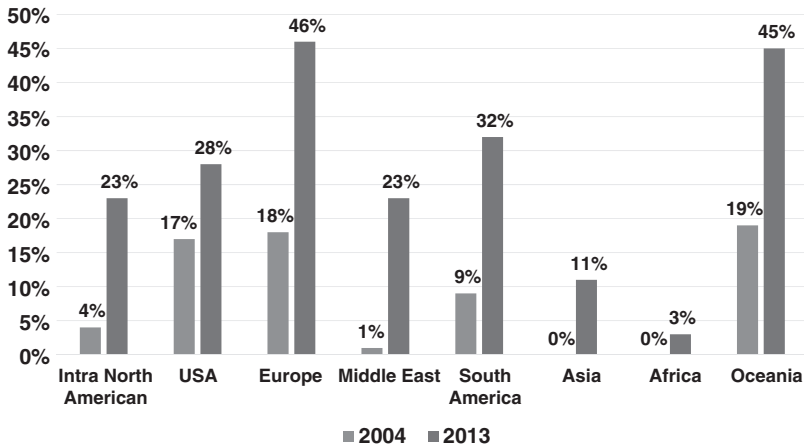


Figure 1.9 LCC share of ASK capacity by world region, 2004 versus 2013. (Data source: Innovata Schedule Reference Service, accessed through Diio Mi)

kilometers (ASKs) within each of the regions shown. (The vast majority of LCCs do not operate long-haul flights between global regions.) While the share of total ASKs offered by LCCs increased from 17 to 28% within the United States, LCCs have grown to a much larger capacity share in other regions. Most notably, LCC shares have increased to 45% or greater within both Europe and Oceania, from less than 20% in 2004. The growth in LCC share has

been even more rapid in South America and the Middle East. On the other hand, the LCC share of intra-region capacity is still relatively small in both Asia and Africa, although increasing especially in Southeast Asia.

1.1.2.2 Emerging Global Airlines

In the first edition of this book, the growth of LCCs and the response of legacy carriers to the new competition from more cost-efficient new entrant carriers was the focus of much of our discussion of global airline industry dynamics. It appeared that the industry would be shaped in large part by the “battle” between established network legacy carriers (NLCs) and rapidly growing LCCs. Since that time (2008), a third sector of the global airline industry has emerged as a major force that is shaping the current and especially future aviation market. We call this sector the “emerging global airlines” consisting of airlines operating from bases in countries outside of established first-world economies. These airlines are based in China, South America, and the Middle East, and have been growing at astonishing rates during the past decade.

Figure 1.10 shows the largest global passenger airlines, ranked by RPK for 2013. Although the biggest US carriers (Delta, United, and American) remained the largest in the world by this measure, the fourth largest passenger airline was Emirates, based in Dubai. With a 14% RPK growth in 2013 compared to 1–2% growth for the three US carriers, Emirates is poised to leap ahead of the US group in the coming years to become the world’s largest airline. The gray bars on the figure identify the other airlines that belong to this new category of emerging global airlines, all of which have recently entered the ranks of the largest world airlines due to sustained high growth rates. China Southern, China Eastern, and Air China, based in the People’s Republic of China, ranked 9, 10, and 12, respectively, and grew by 9–10% in 2013.

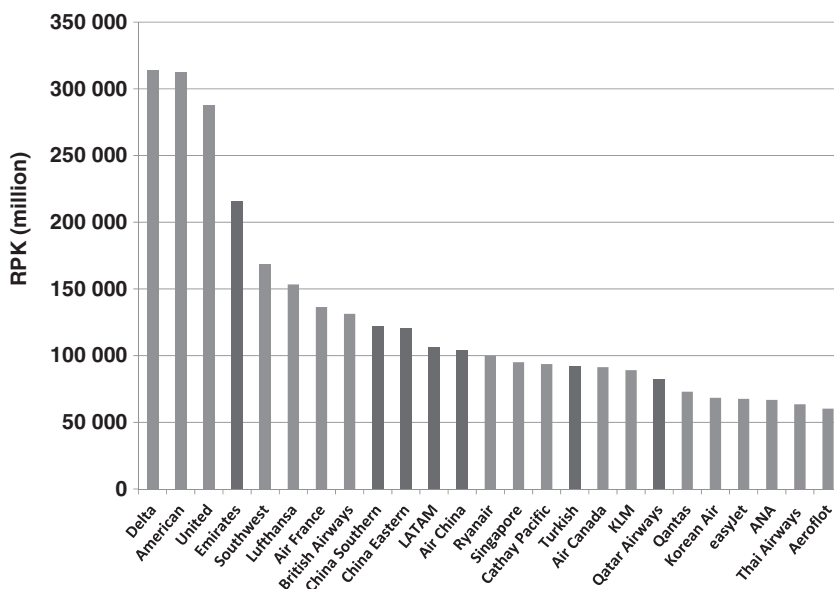


Figure 1.10 Largest 25 airlines ranked by revenue passenger kilometers, 2013. (Data source: Airline Business, 2014)

		Emirates	Etihad	Qatar	Turkish	Average
2007 – 2012	Passengers	12.65%	16.26%	15.83%	13.62%	14.59%
	ASKs	14.19%	18.66%	20.41%	18.30%	17.89%
	RPKs	14.37%	21.84%	19.28%	18.20%	18.42%
	Fleet Size	11.68%	11.50%	16.42%	15.30%	13.73%

Figure 1.11 Annual growth rates of emerging Middle East carriers 2007–2012. (Data source: Al-Sayeh, 2014)

South America's LATAM can be considered an emerging global carrier based on its rapid growth in recent years. Turkish Airlines and Qatar Airways have also leaped into the top 25 with consistently high growth rates over recent years. In 2013, Qatar Airways RPKs grew by 12%, while Turkish Airlines posted a 23% increase in traffic.

The emerging global carriers based in China and South America have been growing at very high rates primarily due to the rapid economic growth and resultant increase in demand for air travel in both regions. On the other hand, the emerging carriers of the Middle East have grown at even higher rates, but with a significantly different strategy for growth. As shown in Figure 1.11, these four airlines – Emirates, Qatar, Etihad, and Turkish – maintained double-digit annual growth rates in passengers, RPKs, ASKs, and fleet size over the period 2007–2012, a pace of growth that has continued in 2013 and 2014, as noted above.

Each of these emerging Middle East carriers has grown as a result of very similar network strategies designed to carry passengers via their respective hub, a major reason why we include Turkish in this group. A large majority of the passengers carried by these carriers on flights to their hubs in Dubai (Emirates), Doha (Qatar), Abu Dhabi (Etihad), and Istanbul (Turkish) are connecting passengers with neither origins nor destinations in the hub city.

The growth of the emerging Middle East carriers has thus been enabled by the power of hub networks to consolidate passenger loads from many different markets onto flights into and out of the hub (see Chapter 7). Their hub strategies allow them to operate mostly large wide-body aircraft, and the location of their hubs gives them a geographical advantage over traditional connecting hubs in Europe. Looking ahead, the combined fleet orders for these four airlines totaled more than 1000 aircraft at the end of 2013, almost 75% of which were for long-haul wide-body aircraft. If all of these aircraft are ultimately delivered and put into service by 2020, the number of passengers carried by this group will more than double. Not only will Emirates be the largest passenger airline in the world, Turkish is now projected to rank 6th, Qatar Airways 7th, and Etihad 15th (Al-Sayeh, 2014).

Just as LCCs changed the competitive dynamics of airline markets in many world regions by offering low fares and introducing innovative operating models emphasizing productivity and cost-efficiency, the emerging global carriers are poised to make a potentially even greater impact. While LCCs focused on short-haul routes within regions, the emerging carriers have grown almost exclusively by capturing long-haul inter-regional traffic between virtually all regions of the globe. Some of their traffic is indeed new air travel generated by economic growth in emerging countries and made possible by the new connections offered by these carriers. At the same time, there is much evidence that a substantial portion of the traffic carried by emerging carriers is being shifted from network legacy airlines, in the

United States, Asia, and especially Europe. The potential impacts of emerging carriers on global traffic flows and market shares could easily exceed the competitive challenges posed by LCCs to legacy airlines.

To summarize, more than three decades after the initial deregulation of US airline markets and the subsequent liberalization of many other markets around the world, the global airline industry remains fragile. Airlines around the world are facing competitive pressures from restructured legacy carriers, new entrant low-cost airlines, and/or emerging global carriers, as already described. The rapid growth of the global airline industry and the continued threat of terrorist attacks make safety and security issues critical to every airline and every airline passenger. And, the need for expanded aviation infrastructure, both airports and air traffic control, is of particular importance to emerging economies of the world such as India, China, Africa, and the Middle East, where much greater rates of demand growth are forecast for both passenger and cargo air transportation. These important challenges – sustaining airline profitability, ensuring safety and security, and developing adequate air transportation infrastructure – will be discussed in more detail in Chapter 17.

1.2 Overview of Chapters

This book provides a comprehensive introduction to the global airline industry for air transportation professionals worldwide, for students in transportation programs, and, more generally, for anyone with a serious interest in the subject. Following the brief review in this chapter of the evolution and recent developments in the industry, Chapters 2–16 offer more detailed coverage of airline economics, management, scheduling, and operations, as well as reviews of the topics of aviation safety and security, airports, air traffic control, environmental impacts, and the international regulatory environment in which the industry operates. The perspective is international, drawing on the authors' extensive experience with airline and air transport issues around the world.

The chapters were written by a group of faculty and research staff currently or formerly affiliated with the Massachusetts Institute of Technology (MIT), recognized for their expertise on the multiple facets of the air transport sector. All are associated with MIT's Global Airline Industry Program (web.mit.edu/airlines). Much of the content of this book is based on materials developed for a first-year graduate subject at MIT, "The Airline Industry," that many of this book's coauthors have been teaching together since 2001. In this second edition, many updates have been included to reflect new developments in the airline industry through 2014.

To provide the reader with adequate background for several subsequent chapters, Chapter 2 describes the regulatory and institutional context within which air transportation must operate. It first presents a brief account of the contributions of the Chicago Convention to the development of the global airline industry and explains the "freedoms of the air" for international air transportation services, in layman's terms. It then reviews the emergence of economic deregulation, privatization of airline companies, and liberalization of international aviation agreements. Emphasis is placed on recent developments, such as Open Skies multilateral agreements and the complicated issues raised by global airline alliances. Similarly, recent trends toward airport privatization and the semiprivatization of air traffic management (ATM) services are discussed, with emphasis on the emergence of infrastructure capacity constraints that can act as a global restraint to competition. The chapter also provides a brief survey of the major national and international government agencies and organizations, and of

the various industry and professional associations that play important roles in shaping the international regulatory environment.

The fundamentals of airline economics, markets, and demands are introduced in Chapter 3. This chapter introduces basic airline terminology and definitions, along with the concepts of air transportation markets and the demand for air travel. The joint supply of service to multiple origin–destination (O-D) markets by any single flight in a network is explained, along with the importance of service quality and total trip time, in addition to price in determining air travel demand volumes. A brief overview of air travel demand models is then provided, focusing on the effects of price and time elasticity, as well as of the cross-elasticity of demand. Finally, factors affecting market share in competitive airline markets are described, and typical approaches for estimating airline market share are introduced – the classical S-shaped market share/frequency model and its extension to Quality of Service Index (QSI) models.

Chapter 4 continues the discussion of airline economics with an introduction to recent developments in airline pricing and revenue management (RM), based on the demand fundamentals introduced in Chapter 3. The theoretical discussion examines price discrimination and market segmentation techniques used by airlines to maximize revenue through “differential pricing” of air transportation services in the same O-D market. The discussion of actual practices explains fare product restrictions with examples of traditional airline fare structures (pre-2000) and of recent trends in airline pricing aimed at simplifying fares in response to LCC competition. More recent pricing strategies that include “fare families” and “merchandising” of ancillary revenues are also described.

Chapter 5 provides a self-contained overview of the basics of revenue management, used by airlines to manage the number of seats sold at different fares. The evolution of computerized RM systems and their capabilities are described, including overbooking models and practices. The most commonly used approaches for fare class optimization on a single flight leg are then presented, followed by extensions to the more complicated problem of network revenue maximization. Recent developments in RM forecasting and optimization required for simplified fare structures of the type offered by many LCCs are also discussed.

The review of airline economics continues in Chapter 6, which is devoted to airline operating costs and productivity measures. With the growth of low-fare carriers and increasing competition worldwide, control of operating costs and measures of productivity have become critical to profitability. The chapter first describes the challenges in categorizing airline operating costs and presents alternative categorization schemes. Based extensively on updated (through 2013) US DOT Form 41 data reported by the airlines, total airline operating costs are broken down by category, and comparisons are made both across airlines (Legacy versus LCC) and across aircraft types. The evolution of LCC business models and the convergence of legacy and LCC costs in recent years are highlighted. The most commonly used measures of aircraft and labor productivity are then defined, and recent trends among Legacy and LCC airlines are used to illustrate these measures and their impacts on unit operating costs.

The next several chapters are devoted to the processes of planning, optimization, and operation of a schedule of services offered by an airline. Chapter 7 first provides an overview of the airline planning process, as it describes major airline planning decisions, from the longest-range strategic decisions involving aircraft acquisition to medium-term decisions related to route planning and scheduling. Approaches to fleet planning are described, and the most important aircraft characteristics considered in fleet selection are discussed. The impacts of several new aircraft types such as the A380 and B787 on airline network growth strategies are

discussed, along with the movement away from small regional jets. Methods for evaluating route profitability are then presented, focusing on the importance of hub economics in the network structure of most large airlines. The advantages and incremental costs of hub-and-spoke operations are also discussed. Hub network strategies are highlighted as the principal driver of the recent growth of emerging Middle East airlines. Finally, the schedule development process is described qualitatively to introduce the major steps of frequency planning, timetable development, fleet assignment, and aircraft rotation planning.

Building on the qualitative introduction to the schedule development process in Chapter 7, Chapter 8 focuses on the models used by airlines to find optimal solutions for several scheduling problems. The fleet assignment model (allocation of the aircraft fleet to scheduled flight legs) is presented first, with both a detailed description of the problem and an advanced section describing network optimization formulations, extensions, and solution methods. The application of these methods to schedule design and retiming of flights is then discussed, and the basics of several related scheduling problems are presented, including the crew scheduling problem (how to minimize the crew costs associated with covering all flight legs in a schedule through “crew pairing” and “crew rostering”) and the aircraft maintenance routing problem (ensuring that aircraft rotate through maintenance bases at the required times).

The smooth execution of the flight schedules developed during the planning process, as described in Chapters 7 and 8, is the responsibility of the flight operations departments of airlines. Chapter 9 presents an overview of airline operations and of the sequence of actions needed to coordinate each airline’s complex combination of aircraft, cockpit and cabin crew, maintenance facilities, and ground service personnel. The work regulations and scheduling of flight crew are described first, providing important background for the remainder of the chapter in which the activities taking place during the different phases of a typical flight are described in more detail. The steps in preparing a flight for departure, followed by pushback, takeoff, cruise, descent and landing, and culminating with arrival at the destination airport, are all discussed with a focus on the role of regulatory requirements and the activities of airline personnel in each step. The impacts on flight operations from recent advances in aircraft and air traffic control technologies and procedures are described, and differences between flight operations in various parts of the world are highlighted.

Despite an airline’s best efforts to optimize and execute a schedule plan, unforeseen disruptions to this plan occur inevitably every single day. These result in “irregular operations.” Chapter 10 is devoted to describing the problems associated with irregular operations and with “schedule recovery” by the airlines. This chapter describes the various reasons for such disruptions, and the delays and economic impacts that can result. It covers two complementary but different optimization-based approaches. The first are schedule recovery techniques – replanning aircraft and crew and passenger routings – designed to optimize the reassignment of disrupted resources. The second are robust planning approaches that reduce the cost associated with schedule recovery by generating schedules during the planning process that are more resilient to disruptions or easier to repair if disrupted. An overview of schedule recovery and robust planning approaches concludes the chapter, along with a summary of recent successes and remaining challenges.

Chapters 11–16 provide a review of several of the most critical considerations facing airlines in the planning and delivery of safe and profitable air transportation services – labor issues, safety and security, airport infrastructure, air traffic control, and the impacts of information technology. Chapter 11 surveys different approaches to labor relations and human resources

management used by airlines around the world. This chapter begins with a general framework for understanding the key aspects of employment relationships at airlines, and then discusses the traditional management–labor paradigm in the airline industry as affected by the unique regulatory frameworks governing airline labor relations around the world. Given this historical context, the chapter discusses alternative models for labor relations and human resource management that have in some cases proven to be more effective. New emphasis is placed on the multiple airline bankruptcies and mergers that occurred around the world between 2005 and 2013 and on how those corporate events have affected the prevalence and viability of the alternative employment models. The chapter concludes by discussing the need to develop an industry-wide approach to the most difficult labor relation problems the airlines face.

Aviation safety and security is essential to the economic viability of airlines, a fact made painfully clear by the events of September 11, 2001. Chapter 12 first focuses on aviation accidents not attributable to terrorist attacks, and presents a set of statistics that address in a global context the critical question of “how safe is it to fly?” Measures for quantifying the mortality risk of passenger air travel are developed and then used to make safety-related comparisons across airlines and nations over the 60-year period from 1954 to 2013. Possible explanations are offered for the large differences that are observed. To illustrate issues in preventing future accidents, runway and midair collision risk are discussed in detail. In its second half, the chapter turns to aviation security, with an overview of approaches used internationally to protect against terrorist acts. The chapter concludes with several examples that illustrate the complexity of making decisions about how much security to provide at airports and on flights.

Chapter 13 presents an overview of the characteristics, operations, and finances of large commercial airports. The objective is to familiarize the reader with a broad range of issues and terminology. Fundamental characteristics of airports in different regions of the world are described first, with emphasis on the contrast between recent explosive growth at many Asian, Middle Eastern, and South American airports and relative stagnation in North America and Western Europe. This is followed by a discussion of airside and landside facilities, including international design standards and specifications. The critical topic of airport capacity is then addressed, both airside and landside. This includes a brief review of airport demand management techniques and of the prospects for congestion relief through improved air traffic management systems and through market-based demand management approaches. Finally, the controversial subject of user charges for airport facilities and services is discussed in the context of airport economics and the financing of capital projects.

Along similar lines, Chapter 14 provides an introduction to the characteristics and operation of air traffic management – better known as air traffic control (ATC). This chapter focuses on the functions and constraints of the ATC system, and on the considerable differences that exist among the ATC services offered in various regions of the world and in different operating environments. The ATC technical infrastructure is described, including communications, navigation, and surveillance systems. The characteristics of airspace and the relationships to ATC structure are then considered, followed by a discussion of ATC operations and standard procedures that affect them. The second part of the chapter explores the relationships between ATC and airport capacity constraints, including the implications for airline scheduling and operations decisions described in previous chapters. An update on the development of “next-generation” air traffic management capabilities around the world is provided in the final section.

Aviation affects the environment primarily through noise and emissions, leading to heavy public and political pressure on the industry to better manage and mitigate such impacts. Chapter 15 provides a review of civil aviation's impacts on community noise, local air quality, water quality, and climate change, along with a summary of the main ways in which these impacts can be mitigated. It begins by describing briefly the local, national, and international bodies that address the environmental impacts of aviation. The different types of environmental impacts are then discussed in some detail, along with an overview of recent trends and of possible mitigation strategies for each type of impact. In particular, we consider recent improvements in operational procedures, trends in aircraft acquisitions and their effect on environmental impacts, and current and projected innovations in aircraft design. Emerging issues concerning the different types of impacts are also explored, with particular reference to recent research and its implications for both regulatory policy and technological development.

Airlines are recognized as leaders in the use of information technology, having developed the large databases and decision support systems introduced in several of the beginning chapters of this book. Chapter 16 first provides a review of the role of computerized systems in airline planning and operations, and then focuses on the evolution of information technology applications for airline distribution and passenger processing. The development of computer reservations systems is described, as background for understanding the dramatic changes in airline distribution that have occurred over the past two decades. The differences between traditional global distribution systems (GDS) and alternative airline distribution channels are explained, and the implications for both airlines and consumers are discussed. The cost reductions attributable to distribution shifts and electronic ticketing are updated. In addition, recent innovations in passenger processing, including self-service check-in, upgrade notification, and baggage tracking, are discussed, with a focus on the implications for airline economics and passenger satisfaction.

Chapter 17 concludes this book with a discussion of the critical issues and prospects for the global airline industry, drawing together the insights provided by the preceding chapters concerning the many constraints, decision processes, and stakeholders that contribute to industry evolution. Recent consolidation in the United States and Europe has returned some airlines to profitability, while continued growth of LCCs and emerging global airlines provide a competitive threat to many others. Liberalized government policies have opened many new markets, but other policies on foreign ownership, labor issues, and protectionism will continue to affect airlines. Looking ahead, the critical challenge for global airlines continues to be the pursuit of sustained profitability across world regions and airline sectors, in the face of a highly uncertain operating environment, while maintaining an excellent safety record and providing an adequate level of service at a reasonable cost to their customers.

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