Chapter 2
Survey of Studies on Airlines and Their Efficiencies

Abstract This chapter takes a closer look at previous studies on the efficiency and competitiveness of airlines. We provide a comprehensive review of the latest literature on airline efficiency, productivity and competitiveness, summarizing the main findings in chronological order. The various aspects of the airlines industry reviewed are classified into: efficiency, productivity, and factor conditions; alliances and market liberalization; market concentration, market power, and competition; and other issues. The review is used to assess the consistency of production and cost functions of airline operation with theory. The review also serves as a guide to estimations of airlines' efficiency and compares these across airlines with different characteristics. Appropriate methods are used to identify determinants of the level of efficiency and their effects.

Keywords Efficiency and productivity · Stochastic frontier functions · Competitiveness · Airline industry · Literature review

2.1 Efficiency, Productivity, and Factor Use

Economic theory mainly distinguishes between three types of efficiency: technical, allocative, and cost. Technical efficiency refers to the effectiveness with which a particular set of inputs is used to produce an output. Allocative efficiency involves selecting the mix of inputs that produce a specified set of outputs at a minimum cost (Battese et al. 2000), and cost efficiency or economic efficiency is largely the alignment of both technical and allocative efficiency (Assaf 2012). A number of sources provide a review of the literature (Schmidt 1986; Kumbhakar and Lovell 2000; Heshmati 2003; Kumbhakar et al. 2015). The methodologies of the estimation can be generally divided into parametric, semi-parametric, and nonparametric estimation methods, cost, production and profits functions, panel data and cross-sections, time-invariant and time-variant efficiency, homoscedastic and heteroscedastic variances, etc. Each category is further divided into a number of specialized cases depending on the specific examples studied and the underlying

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assumptions. This review focuses mainly on the models and methods that are frequently used to analyze the performance of the airline industry.

"Efficiency" can be defined in various ways depending on the perspective employed. We estimate efficiency in following chapters on the basis of the assumption that output is maximized given certain inputs and cost is minimized for a specified level of output (Battese et al. 2000; Kumbhakar and Lovell 2000). A number of studies have estimated technical efficiency using a production function approach since this approach does not require price information. Estimating allocative and cost efficiency requires estimating the cost function, in which case information on the input prices of each airline is required. The availability of such information for academic research is, however, rather limited. An alternative method is to estimate technical efficiency on the basis of input and output quantities, which are relatively easier to access. The use of technical efficiency can be consistent with the measurement of productivity, which involves a technical efficiency change component. In this setting, the distance function can be calculated using either an input-oriented assumption or an output-oriented assumption. At the same time, airlines in general have limited flexibility in setting the measure of inputs, e.g., the number of planes is relatively determined, and in most airlines, labor is also contracted in the short to medium term, with more flexibility in the long term. In such cases, input is treated as quasi-fixed. Therefore, given the assumption of output maximization, with relatively fixed inputs, airlines are trying to produce the maximum possible output. In short, the nature of the airline business is to maximize outputs and revenues from using the given inputs and allocate them optimally across spaces.

A survey of the recent literature reveals a large number of empirical studies that examine the factors affecting the efficiency of airlines. Allocative efficiency has drawn extensive debates among scholars and industry practitioners. Many studies have been conducted on the US and European-based airlines, while there have been fewer studies on other regions, particularly Asia, until the recent years. With China emerging as a major player in the airline industry, as with other industries, Asian airlines deserve due attention and research needs to be conducted to account for the substantial and growing portion of international passenger and cargo traffic in the region.

Methodologically, there is an obvious pattern in the existing studies in that they are largely confined to the nonparametric estimation of allocative efficiency. A number of studies are based on stochastic frontier cost and production functions, data envelopment analysis (DEA), and Malmquist productivity analysis. Depending on the aim of a study, the results derived from the frontier function were used in the second stage with a different methodological approach. These studies tried to seek the source of the various factors affecting key issues such as cost factors, profits, and output. For details on the models and methodology, please see Appendix 2.1, which summarizes the relevant literature for the airline industry.

2.1.1 Stochastic Frontier Production and Cost Functions

In the parametric approach, often a production, cost or profit function is specified and estimated parametrically. The objective is to maximize output, minimize cost, or maximize profit given certain conditions. Each function has different data requirements and is estimated using the Ordinary Least Squares (OLS), Corrected Ordinary Least Squares (COLS), Generalized Least Squares (GLS), or Maximum Likelihood Estimation (MLE) methods.

The Stochastic Frontier Analysis (SFA) is an analytical method that employs econometric (parametric) techniques whose models of production and cost recognize the technical inefficiency and the random shocks that may impact the output or cost (Coelli 1996; Kumbhakar and Lovell 2000). In contrast to nonparametric approaches that assume decisive frontiers, SFA permits for deviations from the frontier, whose error can be decomposed for suitable discrepancy between technical efficiency and random shocks—e.g., labor or capital performance variations. In other words, stochastic frontier models permit an analysis of technical inefficiency in the framework of production and cost functions. Production units (firms, industry, regions, countries, etc.) or cost units are assumed to produce according to a given technology, and reach the frontier when they produce the maximum (spend the minimum cost in the case of the cost model) possible output for a given set of inputs (Coelli 1996). Inefficiencies are highly correlated with structural problems or market imperfections and other factors that cause firms to yield less than the maximum possible output. SFA is therefore both a theoretical and a practical framework, whose objective is to define and estimate production and cost frontiers (Constantin et al. 2009). Koopmans (1951), Debreu (1951) used SFA, while Farrell (1957) was the first to measure production efficiency empirically. Aigner et al. (1977), Meeusen and van de Broeck (1977) introduced the SFA with a decomposed or an error component structure. Schmidt (1986), Kumbhakar and Lovell (2000), Heshmati (2003), Kumbhakar et al. (2015) provide comprehensive reviews of the literature. Battese and Coelli (1988, 1992, 1995) also provide a complete list of diverse applications of stochastic frontier models. The specification and application of production and cost models will be further reviewed in relation to estimation of models in later chapters.

Coelli et al. (1999) evaluate the efficiency of international airlines. They obtained technical efficiency scores from stochastic frontier production functions that were adjusted to account for environmental influences such as network conditions and geographical factors. The paper proposed two alternative approaches to the efficiency measurement—environmental factors influence how technology is shaped and they directly determine the level of technical inefficiency. The two sets of results provided similar rankings of airlines but derived distinctive degrees of technical inefficiency. The results also suggested that Asian/Oceanic airlines were technically more efficient than European and North American ones but that the variances are primarily due to more favorable environmental conditions. It was among Asian companies that the major improvements in managerial efficiency (technical efficiency with environmental factors netted out) took place over the sample period (1977–1990).

Oum and Yu (1998) compared unit cost competitiveness of the world's 22 major airlines over the period 1986–1993. They described the methodologies for estimating a neoclassical cost function and for decomposing the unit cost differentials between airlines into potential sources. Their study computed a unit cost index for aggregate output via a multilateral index procedure. A translog variable cost function was then estimated and the result was used to decompose the unit cost differentials into potential sources, input prices, network and output attributes, and efficiency. The results of the unit cost decomposition were again utilized to build a cost competitiveness indicator after removing the effects of network and output attributes. The key findings of the study are as follows:

- Asian carriers (except Japan Airlines and All Nippon Airways) were generally more cost competitive than the major US carriers, mostly due to their substantially lower input prices.
- Japan Airlines and All Nippon Airways were more than 50 % less cost competitive than American Airlines, largely because of their high input prices.
- Among European carriers, British Airways and Scandinavian Airlines Systems were 7 and 42 % less cost competitive, respectively, compared to American Airlines, largely due to higher input prices and lower efficiency.
- Among the US carriers, American Airlines, United Airlines, and Delta were similar in cost competitiveness, while Northwest and Continental enjoyed a 5 and a 12 % cost competitiveness gain over American Airlines.
- Exchange rate fluctuation has had considerable effects on the cost competitive position of Japan Airlines and German Lufthansa.

In another study, Oum et al. (2005) measured and compared the performance of 10 major North American airlines in terms of residual total factor productivity (TFP), cost competitiveness, and residual average yields during the period 1990–2001. Revenue Ton Kilometers (RTK) of passenger, fright, and mail service, including nonscheduled services, were used as output data. In order to incorporate incidental services into the estimation, a quantity index of incidental services output was constructed by deflating the incidental revenues with the US GDP deflator and adjusting by purchasing power parity (PPP) index. Labor, fuel, materials, flight equipment, and ground property and equipment (GPE) were employed as input variables. The number of full-time equivalent (FTE) number of employees was used for the labor input data. The following are the key findings of the study:

- North American airlines improved productive efficiency by about 12 % between 1990 and 2001 despite the substantial reduction of residual TFP between 2000 and 2001.
- Airlines need to perform well in both production efficiency and pricing to be financially successful.
- The significant productivity improvement in the 1990s enabled the airlines to cope with rising input costs and down pressure on returns.

- Airlines that aggressively expanded fleet in response to the fast-growing market during the mid-1990s suffered loss of productive efficiency.
- The 9/11 terrorist attack led to significant reductions in the airlines' yields, which in turn contributed to declining productivity and increasing unit cost.

The airlines scheduling model is estimated by Yan et al. (2008). The model includes solution algorithms based on the stochastic demand model to determine the optimization of the flight schedule of airlines. The study suggests that in order to have a well-planned flight schedule, airlines not only have to consider their fleet supply and related operations, as well as market share, but also account for stochastic variations caused by daily passenger demands in actual operations. It indicated that many earlier studies on short-term flight scheduling used the average passenger demand as an input to create the final timetable and schedule, which means that daily passenger variations in real operations were ignored. Yan et al. (2008) produced a stochastic demand-scheduling model to accommodate such stochastic disturbances and employed arc-based and path-based schemes to foster two heuristic algorithms, useful to solve the problem (Yan et al. 2008). The test results, based on a major Taiwan airline's operation, showed the desirable result in the performance of the model and the solution systems (Yan et al. 2008).

Another example of the parametric approach is that by Assaf (2009) who analyzed the technical efficiency of the US airlines using a Bayesian random stochastic frontier model with data covering the period from 2003 to 2007. A Cobb–Douglas production function was adopted to represent the frontier production technology. He used two outputs together—passenger service and cargo operation together, four inputs—total operational cost (excluding labor cost), labor cost, aircraft fuel and oil expenses, and the number of planes (proxy for capital input). Load factor (RPK/ASK) was similarly appended to the frontier model to evaluate the effects of environmental features which the airlines are able to control. The technical efficiency results showed that US airlines were running at a declining efficiency rate, with an average of 69.02 % of the airlines operating with best-practiced technology.

2.1.2 Nonparametric Approaches

The parametric approach has certain advantages over the nonparametric estimation as it can use environmental factors of the airline, industry, markets, and production rather than simple inputs and outputs in the estimation of efficiency. The disadvantage is that one must assume a functional form, which may not be correctly chosen, thus biasing the inference. However, one can test different functional forms and their generalizations.

Many of the recent Nonparametric Approaches on airline efficiency studies centered on the estimation of airline efficiency or productivity using the application of DEA. They mostly conducted the allocative efficiency test, followed by a second stage to analyze the impact of the other variables of interest on the efficiency level.

Considering the nature of airlines, which operate with multiple inputs and outputs, this approach can address the problems of spurious results and multiple equilibriums. Several studies have focused on the technical efficiency of a route or a city pair, with relatively fewer focusing on the aggregated level of analysis of the airlines' efficiency.

Barbot et al. (2008) studied the efficiency and productivity of 41 international airlines by grouping them into 4 regions.[1] The authors compared the efficiency and productivity of full-service carriers with low-cost carriers. For the empirical analysis, two different methodologies—DEA and TFP—were used. They also investigated which factors account for differences in efficiency. The result revealed that low-cost carriers were more efficient than full-service carriers. Efficiency and the dispersion of both DEA and TFP indices amongst airlines differed by geographical location. The authors argued that different legislation and deregulation processes were the main causes of the variance. As for specific competitiveness factors, labor was the only input that had a statistically significant effect on the level of productivity. Finally, larger airlines were found to be more efficient due to the economies of scale. Labor (number of core business workers), fleet (number of operating aircraft), and fuel (in gallons consumed) were used as measures of inputs, while available seat kilometers (ASK), revenue passenger seat kilometers (RPK), and revenue ton kilometers (RTK) were used as measures of outputs.

The study by Greer (2009) also used DEA and evaluated technical efficiencies of airlines by transforming inputs (labor, fuel, and fleet-wide seating capacity) into ASK (available seat-miles). The paper used data of passenger airlines in the US and employed the Tobit regression model to identify determinants of the efficiency score. This analysis defined variables in terms of physical units instead of monetary values. The result showed that the impact of unionization on airline efficiency was statistically insignificant when control variables such as the average age of an airline's fleet, the average size of its aircrafts, and the average stage length were included as determinants of inefficiency.

Lee and Johnson (2011) propose a two-dimensional efficiency decomposition (2DED) of profitability for a production system. They tried to assess the demand effect observed in the productivity data of the US airline industry from 2006 to 2008. The first process identified four components of efficiency: capacity design, demand generation, operations, and demand consumption, using Network DEA (Network DEA). The second process decomposed the efficiency measures and integrated them into a profitability efficiency framework. Each constituent of profitability transformation was evaluated on the basis of the changes in technical efficiency, scale efficiency and allocative efficiency. The result showed that the decline of productivity was mainly caused by a demand fluctuation in 2007–2008 rather than loss of technical productivity.

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[1]They grouped airlines using the regional classification of the International Air Transport Association (IATA). The regions and their respective number of airlines are Europe and Russia (21 airlines), North America and Canada (11), China and North Asia (8), Asia Pacific (7), and Africa and Middle East (2).

Wang et al. (2013) studied the links between the operating performances of 30 US airlines and corporate governance. DEA was employed to measure the relative efficiency of airlines and to investigate the contribution of inputs and outputs that affect technical efficiency. Efficiency decomposition, combined with cluster analysis and multidimensional scaling, was utilized to explore the competitive advantage of the airlines. Furthermore, they examined whether corporate governance has an impact on the airlines' performance. They concluded that more than half of the thirty US airlines examined were less efficient than the best-performing airline in the industry. The performance of carriers was not just related to internal characteristics such as the number of committees and nonexecutive directors but also affected by external factors.

Cristina and Gramani (2012) runs a two-phase DEAto separately examine the operational and fiscal operations of airlines. The study empirically analyzed the data of 4 airlines—2 Brazilian and 2 American—observed between 1997 and 2006. To measure operational performance, the input-orientation model was embraced and the optimization of the resources in producing a gifted layer of production was investigated. On the other hand, to measure financial performance, the study used the output-oriented DEA model where output is maximized for given inputs and technology. It employed the VRS model (variable returns to scale) instead of CRS (constant returns to scale) since an increase in inputs did not generate the same increase in outputs. Aircraft fuel, wages, salaries and benefits, and cost per available seat mile (CASM) were used as input variables and revenue passenger mile (Load Factor/Available Seat Mile) as output variables in the estimation of operational performance. When investigating financial performance, the inverse of the efficiency scores obtained from the first process was used as an input, while flight revenue and flight income were used as output variables. The result revealed that for emerging markets, operational performance is better than financial performance, implying that resource optimization has been the main concern of the airlines. The study underlined that improving operational efficiency does not inevitably translate into improvement in financial efficiency in emergent airline markets.

Assaf et al. (2009) have measured the efficiency of UK airlines, which have experienced difficulties in recent times. They evaluated the technical efficiency of airlines by applying DEA and employing the bootstrap methodology. In calculating the dispersion of estimated efficiency points, they find the airline size and load factor to be positively linked with technical efficiency. In addition, factors such as higher oil prices and fierce market competition were also potential causes of technical inefficiency. This paper added to the previous studies on the measurement of efficiency and is relevant to the other chapters in this volume. For a list of various important studies on airlines' efficiency, see Table 2.1.

Merkert and Hensher (2011) evaluated the key determinants of the efficiency of 58 passenger airlines by applying a two-stage DEA with partially bootstrapped random effects to estimate standard errors for the point efficiency estimates. They deployed a Tobit regression to estimate the second stage and explain variations in the level of efficiency. This study aimed to evaluate the factors that influence the costs and efficiency of airlines in the highly competitive and challenging airline

Table 2.1 Previous studies on the measurement of airlines efficiency

Study	Inputs	Outputs	Other variables
Coelli et al. (1999)	Labor, capital	TKA	Load factor, aircraft capacity
Ahn et al. (1997)	Labor, materials fuel	Revenue	Load factor, aircraft size
Good et al. (1995)	Labor, materials planes	Revenue	Load factor, aircraft size
Baltagi et al. (1995)	Capital, labor	TKA	Load factor, aircraft size, hubs, mergers
Cornwell et al. (1990)	Labor index materials, energy, capital expenses	TKA	Stage length, service quality, seasonality
Schmidt and Sickles (1984)	Labor index materials, energy, capital expenses	TKA	Size, load factor

Source Assaf et al. (2009)
Note TKA ton kilometers available

industry environment arising from the global financial crisis, the growth of low-cost carriers, and the high and volatile fuel prices that represent a substantial cost pressure for airlines. As for input data, they use available ton kilometers (ATK) as a proxy for capital, in line with the existing literature, and FTE staff as a measure of labor. The two output measures revenue passenger kilometers (RPK) and RTK were used in all three DEA models.[2] For the second-stage explanatory variables, they use available seat kilometers (ASK) to measure the size of each airline. While the average stage length, measured in kilometers, was chosen to evaluate the impact of route/network optimization on airline efficiency, aircraft size measured in terms of average seats per aircraft across the operating fleet, was also selected to test whether the earlier discussed productivity measures of individual aircrafts would have an impact on the overall airline efficiency.

Results of the study by Merkert and Hensher (2011) showed that not only the size of airlines but also the fleet mixes of the size of aircrafts and the number of families of aircraft in the fleets have an impact on technical, allocative and, ultimately, cost efficiency. Although stage length had an impact on an aircraft's unit cost, its impact at the airline level was limited to technical efficiency. Conversely, the age of fleets had no significant impact on technical efficiency, but it delivers, on average, a small positive effect on the allocative and cost efficiency components. The analysis of individual efficiency scores yielded examples of very young fleets achieving relatively high efficiency. The authors concluded that airline managements that aim to reduce costs should focus less on stage length and fleet age and more on other variables, particularly the optimization of the fleet mix. They suggest that the effects of route optimization[3] are limited to technical efficiency. The results

[2]These are commonly used to reflect the output of both passenger and cargo (including mail) flight operations.

[3]They used the average stage length of the fleet as a proxy for measuring route optimization.

from this research showed that airline size and key fleet mix characteristics, such as aircraft size and the aircraft fleet series, were more pertinent to successful cost saving by airlines since they had significant impacts on all three types of airline efficiency. The results also exposed that despite the fuel-saving benefits of a younger aircraft, the age of an airline's fleet had no significant impact on its technical efficiency but did have a positive impact on its allocative and cost efficiencies.

In a recent study, Merkert and Williams (2013) applied a two-stage DEA approach and analyzed the efficiency of 18 European Public Service Obligation (PSO) airlines over two financial years (2007/08 and 2008/09). They used truncated regressions to determine the impact of specific airline characteristics and their 206 PSO contracts on efficiency. They wanted to investigate whether individual PSO operators functioned competently because most of these services are important for the social and economic development of the relevant regions. The data suggested that apart from a small number of contracts with international traffic in France, Ireland, and Finland, PSO routes were usually operated domestically by local (national) carriers and often connect different islands with the mainland. In terms of aircraft, some carriers in France, Italy, Portugal, and Spain used much bigger aircraft (e.g., A320) than carriers from other countries such as the UK. This substantial heterogeneity across countries/operators has implications for the average distance flown. In terms of data for the first-stage DEA analysis, the authors used two inputs, ASK[4] and FTE,[5] for staff employed in the relevant period. Outputs were estimated with revenue passenger kilometers (RPK) and realized departures. The results suggested that ownership has no impact on airline efficiency. By contrast, the number of remaining months before a PSO is due for renewal in these contracts has a very significant positive effect. The effect of the stage length to the efficiency of the associated airlines showed a negative impact.

In another recent study, Duygun et al. (2015) applied network DEA models and studied efficiency and productivity issues in 87 European airlines from 23 European carriers during the period 2000–2010. While estimating the impact of airline market liberalization, the influence of several events, such as the 9/11 attacks in 2001 and the global financial crisis of 2008, on the performance of European airlines had to be taken into account as they happened during the sample period. To overcome the shortcomings of the DEA estimation, which they regarded as "disentangling the black box or production process," they employed two basic stages. In the first stage, inputs consumed by airlines for delivering services (such as seats kilometers) were used. They find that the decision to use the level of service or customer satisfaction together with the level of quality offered in their previous travel experiences differ across the organization, thus they used them as a second input. In sum, they found

[4]Available seat kilometers to measure the offered capacity of each operator.

[5]As a proxy for employed capital and full-time employment.

that most inefficiencies are produced in the first stage of the analysis. However, when taking into account the various types of carriers, several differences emerge, with most of the budget carriers' inefficiencies are confined to the first stage. The estimation also revealed that performance of airlines is very dynamic since efficiency varied across types of airlines during 2000–2010.

Finally, Mallikarjun (2015) applies the un-oriented DEA network methodology to assess the operating efficiency and performance ratios as well as the sources of inefficiency of 14 major and 13 national US airlines. The results of the study suggest that major US airlines captured better efficiency than national US airlines in terms of spending operating expenses and gaining operating revenue, while there was no meaningful variance in their service provision and efficiencies of the demand.

2.1.3 Malmquist Productivity Analysis

Productivity measurement is different from efficiency measurement. Productivity is a measure for single factors such as labor, energy, and capital or multiple factors termed as single factor productivity (SFP) and multiple or TFP respectively. It measures the output per unit or aggregate units of inputs. Productivity studies are interested in yield per unit of input and its development over time. One can compare the productivity of two units in the same period or of the same unit over different periods. Productivity is linked to efficiency by its decomposition into scale, technical change, and efficiency changes. Productivity measure can be estimated parametrically from the production of cost function or nonparametrically using the Malmquist productivity analysis. For reviews of the literature, see Kumbhakar and Lovell (2000), Heshmati (2003).

Pires and Fernandes (2012) applied the Malmquist productivity index to estimate the financial efficiency of 42 airlines from 25 countries in 2001 (the year of 9/11) and their profitability in the following year. The Malmquist productivity index was used to investigate changes in the airlines' capital structure from 2001 to 2002. The results showed the airline capital structure management and profitability dynamics following the unexpected shock of 2001. Their main conclusion was that airlines which moved more aggressively to reduce their indebtedness showed improved profitability, for a given size, fleet, and intangible assets. In order to expand their air transportation operations, airlines require substantial financial investments, especially in aircraft, fleet maintenance, and information systems. To meet the passenger and cargo demands adequately, the authors suggested that the system must have an equilibrium that reconciles these and other factors such as operating costs and expenses, fleet suitability for each route, and company profitability.

2.1.4 Other Performance Measurement Methods

Despite the global trend toward deregulation, barriers to entry in the air transportation industry, particularly in the domestic markets, still remain high. Recently, productivity issues in the industry have been much explored by many researchers due to increased competition facing the industry, particularly in the international market. Current research on airline productivity has centered on two aspects: drivers of productivity variations and sources of productivity growth. In addition, a number of studies have examined the inadequacy of TFP as an indicator of financial improvement. These studies suggest that unit cost competitiveness and average yield indexes should be used together with TFP to get a better indicator of the performance of airlines.

Employing an alternative performance measurement method, Gorin and Belobaba (2004) investigated the effect of airline revenue management on traditional measures of airline market performance and explored the dynamics of airline markets, especially with respect to competition issues. They emphasized the role of revenue management and the new entrants' capacity in market competition. They criticized existing measures of incumbent carriers' anticompetitive actions by pointing out that "it did not constitute a reliable indication of the response of incumbent carriers and provided even less information on the strategic intent of the incumbent carriers." Their results implied that even airline-specific average fares, traffic, and revenues provide an incomplete picture of the effects of entry into a market, contrary to the findings of previous researchers.

Many of the studies cited above showed the importance of identifying factors influencing the performance of airlines. Gudmundsson (2004) studied factors associated with airline performance through an exploratory factor analysis. A two-level bottom-up hierarchical approach was used in the empirical study. The results showed that airlines with a higher relative score on productivity and brand image were less likely to be under financial distress, while airlines with a higher relative emphasis on market power were more likely to be under financial distress affecting the airlines' performance.

An empirical time series analysis of airlines' performance is rare. Okulski and Heshmati (2010) performed a time series analysis on the technology efficiency of the airline industry by using monthly data from January 2001 to April 2009 for a large panel of 130 airlines. The results showed that specialized passenger airlines could not obtain sufficient revenues to stay in the market for a long period of time. Airlines can reduce costs by adding additional products to the scope of their services. Even the worst performing joint service airlines performed better in carrying passengers than specialized best practice airlines. Therefore, in order to increase profits and improve survival chances, airlines specializing solely in passenger transportation must diversify their business and carry both passengers and cargo.

Quality and its measurement are often neglected in analysis of performance of the service industry. Parast et al. (2010) investigated both the effects of quality on profitability and the effect of productivity in the US airline industry using with

Table 2.2 Various output measures used in airline industry

Output measures	Passenger-miles and ton-miles
Proxy for productivity	Labor productivity
Measure of quality (conformance quality)	On-time performance[a]
Measure of operational cost	Gas price (average of year)
Measure of operational cost	Employee salary (average of year)
Measure of profitability	Passenger load factor[b]
Measure of operational cost	Maintenance cost per flight hours[c]

[a]The percentage of flights that were departed on-time (less than 15 min late)
[b]The number of passenger-kilometers traveled as a percentage of the total seat-kilometers available
[c]The average cost of maintaining the aircraft divided by the total number of flight hours per year
Source Parast et al. (2010)

panel data from 1989 to 2008. The results showed that labor productivity was the most significant predictor of profitability, while on-time performance had no relationship with profitability. The findings identified "labor productivity, gas price, average annual maintenance cost, and employee salary" as the most significant explanatory variables or predictors of profitability. The authors found a progressive impact of labor productivity and employee wage on profitability, while gas price and average annual maintenance cost were regressive to the level of profitability. As for methodology, they employed a correlation and multivariate regression analysis to measure the effect of airlines' operations and expenses on productivity and profitability. Stepwise regression was applied to assess the significance of each variable. Labor productivity, which is the output per unit of labor, is derived from dividing output by an extent of the labor input, typically labor hours (see Table 2.2 that provides a list summarizing the variables used for the empirical estimation of this study).

There is a plethora of studies on US airlines. Powell II (2012) evaluated the productivity performance of US passenger airlines since the airline deregulation in 1978. The paper measured and compared productivity at both the aggregate US airline industry and individual carrier groups. Productivity was measured at the aggregate airline industry level in terms of multi factor productivity (MFP) the ratio of a single output to a combination of inputs, in order to track industry productivity over from the period 1978–2009. In addition, productivity was measured at the dismantled carrier level in terms of TFP and the ratio of total inputs over total outputs in order to compare productivity growth across airlines and over time from 1995 to 2010. The key findings indicated that US passenger airlines experienced tremendous MFP improvements since deregulation despite periods of reduced productivity levels that coincide with exogenous shocks such as economic recessions, fuel price spikes, and other unforeseen events with negative impacts on airline productivity. Between 1978 and 2009, cumulative MFP in terms of airline traffic revenue passenger miles (RPMs) and network capacity available seat miles (ASM) increased by 191 and 117 % respectively. This implies that US passenger airlines have at least doubled their productivity over the past three decades. The paper argued that if RPMs are used as the measure of output, productivity increase would almost triple.

Demydyuk (2011) reviewed metric measures commonly used for analyzing the performance of the airline industry. In particular, this study examined the effectiveness of models based on two activity drivers—passenger-based revenue drivers and kilometer-based cost drivers. The study covered 27 top carriers over a 5-year period. The data was clustered according to airline type, region of origin and operation, and strong or weak financial performance. It was then analyzed in terms of specific properties, followed by a correlation analysis for three data clusters. The variables were then tested to assess the multicollinearity and fixed endogenous problems. Twelve multiple regressions were run on each data cluster with two different dependent variables, namely, operating margin percentage and returns on assets percentage. The main results indicated that operating profit per passenger or per passenger-kilometer was the most significant predictor of airline profitability compared to revenue, unit cost, and load factor, which are conventionally used by the industry. There was no significant correlation between size, business model, or region, which would explain low or high profitability of an airline. According to the regression analysis, seats were not found to be a better denominator than passenger-kilometers, since the analysis showed that operating profit per passenger-kilometer fits the industry better. A central finding is that operating profit per passenger was almost as good as operating profit per revenue passenger kilometers (RPK) in evaluating airlines' financial performance.

Service quality and sensitivity analysis are helpful in estimating performance accurately. Liou (2011) applied MCDM (multivariate statistical analysis and multiple criteria decision-making) methods to analyze airline strategies for passenger services based on passenger preferences. The study used the VC-DRSA (Variable Consistency Dominance-based Rough Set Approach) as the basic empirical framework. Flow graphs were applied to infer decision rules and variables. A large number of alternative approaches and specifications were employed to validate the robustness of the performance results obtained.

Nath (2011) proposed a way to resolve the conceptual and practical problems associated with the quantification of airlines' productivity. He claimed that conventional methodologies to quantify productivity change were inadequate. Quantifying productivity with different units of measurement, such as output per man hour, output per machine hour, and output per unit of material consumed, posed aggregation and disaggregation problems. As a solution, he proposed economic productivity measurement models for the simulations, the use of which significantly improved the estimation results.

In general, the entire airline industry is expected to suffer from immediate and lasting effects as a result of the outbreak of a recession. Pearce (2012) examined air transport markets and the airline industry after the recession of 2008–2009. This paper found that the demand for air transport has been robust in the face of repeated external shocks. International air travel and airfreight rebounded to prerecession levels within 18 months after the recession. Air travel has remained income elastic. Globalized business supply chains have continued to depend on fast air cargo services. Airlines have adjusted their fleet to overcome the demand shock. Capacity was cut, though largely by underutilizing aircraft, which accentuated financial losses. Cash flows in many regions have recuperated although returns on capital stayed below the industry's weighted average cost of capital. Pearce found that competition was restricted to parts of the supply chain that were identified as the primary source of inadequate airline profitability. The author concluded that the value created by the air transport industry has become indispensable to consumers and the wider economy.

Many studies have investigated the impact of an airline's business model, mostly by comparing full-service carriers and low-cost carriers. Different business model imply different cost structures, and this issue has been investigated in conjunction with airline efficiency. A business model reflects the degree of flexibility and independence in decision-making. Most studies have adequately addressed such structural differences using various approaches.

2.2 Alliance Formation and Market Liberalization

It is generally agreed, at least by the advocates of the free market economy, that liberalization of the air transport market leads to increased efficiency. Liberalization eases entry barriers against potential carriers and new carriers, therefore leading to high competition levels in the market. In order to attract a high volume of passengers, airlines have to cut costs and deliver a lower fare as well as a better service quality. Otherwise, passengers will turn to competitors who offer better prices and service quality. The findings from the literature reveal a direct or indirect effect on airline efficiency from opening up of the market. With regard to the effect of liberalization on airline efficiency, most studies have focused on markets in the United States and Europe probably because airline liberalization in Asia began only after 2000. So far research on open skies has centered on the challenges faced by airlines under an open skies agreement and the determinants of a successful open skies initiative. While market liberalization in general and open skies policies in particular met with a degree of success in both the US and Europe, more studies are required on the Asian market. Asia is a relatively latecomer in joining the market liberalization trend, and therefore it deserves further investigation on the progress it has made so far. An additional area that merits a closer look is the prospects of the open skies movement in Southeast Asian economies.

Kontsas and Mylonakis (2008) examined the impact of bilateral agreements on some European air routes in terms of price competition and market structure. They described a theoretical model of firm behavior in the airline industry, both in collusive oligopoly and noncooperative settings. The proposed model explained firms' behavior in the air services market and their characteristics in demand and pricing policies. The results showed that prices were determined by the mark-up on standard cost variables, and the mark-up was in turn determined by customers' goodwill.

In another related study, Fu et al. (2010) studied the traffic volume and traffic flow patterns in relation to the impact of the liberalization policies on economic growth. They investigated the mechanisms driving these changes. The main findings of this study are summarized as follows:

- Liberalization brought extensive economic and traffic growth. Such positive effects are primarily because of the extensive competition and efficiency gains in the airline industry, as well as positive externalities to the economy.
- Liberalization allows airlines to optimize their networks within and across continental markets. Consequently, traffic flow patterns will be transformed accordingly. Strategic alliance is an alternative counter measurement and will weaken when ownership and citizenship restrictions are relaxed.
- There is a two-way association between the expansion of low-cost carriers (LCCs) and liberalization. The paper found that the prevailing growth of LCCs leads to intensified competition and expanded traffic, demanding the removal of restrictions on capacity, frequency, and ticket-charging practices. In addition, it concluded that by increasing the competitiveness of the national aviation industry, emerging and future development of LCCs in the domestic market would also promote the liberalization policy. Such a perspective views the existing regulations as the cause of hindrance to LCCs' growth. More active liberalization should therefore be undertaken for the full realization of associated gains.

A common form of airline cooperation in the wake of the global trend toward liberalization in the air transport market is an increased tendency to form alliances. This is attributed to substantial regulations and the need to form a global network as a way of getting around the wide range of restrictions—legal, political, and institutional—that stand in the way of mergers and acquisitions in the aviation market. Airline alliances can have a positive impact on economic welfare, better services due to improved coordination among the airlines (e.g., flight connections) and lower unit costs. The studies find a strong evidence of efficiency gains derived from economies of scale, evident in increased passenger volume, reduced average air fare, and positive structural changes.

Consolidation and alliance formation is another aspect that plays a role in enhancing airlines' survival and competitiveness. Fana et al. (2001) examined the prospect of various aspects of airlines' consolidation and alliance developments. They conceptualized the most viable near-term airline alliance and consolidation scenario along with a possible scenario of evolution. They showed that economic factors of the industry would force airlines into a superior degree of consolidation, subject to the bound of regulatory liberalization in passenger air transport and the public's opposition to competition.

In a related study, Whalen (2005), using eleven years of the US and European region's data, estimated the various effects of airline code sharing, antitrust immunity, and open skies treaties on prices, output, and capacity. The estimation results showed that code sharing and immunized alliances were statistically significant in lowering the prices compared to traditional interline or multicarrier services, but the estimated size of the effects was significantly smaller than previous results.

Gudmundsson and Lechner (2006) investigated multilateral airline alliances through the lens of structural holes and network closure. The structural holes theory sees network ties as opportunities that link separate network segments through brokers and weak ties. The contrary view argues that network closure would generate superior social capital and thus superior economic rent since there would be more trust, reputation and cooperation within a closed group with strong internal ties. The authors argued that the two perspectives in combination can advance the ability to explain alliance processes in the airline industry.

Sjögren and Soderberg (2011) looked at how deregulation, privatization and the formation of strategic alliances have affected the productivity of international airlines. They evaluated the three factors simultaneously and disaggregated the carriers' operations into production and sales, allowing for firm-level heterogeneity through random parameters. This study used the annual data of 50 major international airlines during the period from 1990 through 2003. Estimations of stochastic frontier models revealed that at the aggregate level, deregulation increased productivity; membership in alliances had an ambiguous effect; and state ownership had no significant effect. Disaggregating the carriers' operations confirmed the productivity gains from deregulation but indicated less clear-cut positive effects for state ownership and alliances.

Finally in a more recent study, Bilotkach et al. (2012) discussed some antitrust implications of airline alliances. They categorized airline alliances in accordance with consumer benefit and the supply side, and discussed their main competitive effects. They concluded that most types of efficiencies can only be considered as partly immunity-specific and suggested an assessment of only the economic effects of antitrust immunity.

2.3 Market Concentration, Market Power and Competition

In any industry, companies can compete on the basis of lower costs, higher quality, or product innovation (see Porter 1990). In the airline industry, depending on the market situation, airlines choose the best strategies to expand their market share in the face of competition. Due to the importance of market share and market power, many studies have analyzed this issue. The analysis makes use of various tools and methodologies in evaluating the effects of market concentration, market power, and competition on airlines' performance.

In an early stage of performance evaluation, Graham et al. (1983) estimated the same type of equation used by Douglas and Miller with the data sample of 324 airline markets. In this paper, they used the Herfindahl–Hirschman Index (HHI), based on carriers' shares of departures, to measure market concentration instead of the number of carriers that Douglas and Miller relied upon. They also estimated load factor equations for the years 1976 and 1980 by applying OLS and two-stage least squares (2SLS). Due to the possible correlation between the density variable and the error term, the use of 2SLS was suggested as the better approach to deal with the endogeneity problem. The results showed that high load factors reduced service quality and thereby reduced traffic. The Herfindahl–Hirschman Index was treated as exogenously determined.

Captain and Sickles (1997) studied the market power of European airlines in an oligopoly structure with product differentiation for the period 1976–1990 and tested the monopoly hypothesis. This paper analyzed the level of competition among eight major European airlines and found little evidence of market power in the industry over that period. The main findings of this paper was that the high prices in Europe were not entirely due to the bilateral agreements, possibly leading to monopoly power, but probably a result of very high cost structures in the industry. These results were inconsistent with the previous study conducted by Good et al. (1994) who examined the same issues in European airlines by estimating a structural, two-stage game—that is, a demand function which incorporates cost and market power as explanatory variables.

In an Asian market context, Chan (2000) reviewed competition in the air transportation market, focusing on the strategy of competition. This article looked at the degree of the competition in the air travel industry located in the Asia Pacific and its impact on the economy in the 1990s. The author investigated and explained the causes of the region's explosive market growth. The air travel share in Asia exceeds 40 % of global travel, rising to 50 percent in 2010. IATA (International Air Transport Association) also projected that the growth rate of international scheduled passenger numbers in Asia will be an average of 7.1 % annually.

Clougherty (2001) empirically tested whether globalization undermines the autonomy of domestic airline competition policy. With a panel data set of twenty-one nations over the 1983–1992 period, his analysis yielded two major findings: (1) globalization undermines the autonomy of domestic airline competition policy and (2) government institutions mediate globalization's impact. The empirical tests reported in this paper utilized a random-effects specification to capture firm-specific effects, after a series of Lagrange Multiplier and Hausman tests, along with a defined period-effect to account for time-specific trends. Three additional econometric issues—nonlinearity in the explanatory variables effects, multicollinearity concerns and confounded effects—and the static nature of the domestic market structure were also addressed. The report concluded that globalization increases the importance of international competitive effects, and private and public interest related political forces are more likely to back consolidation when international competitive effects are important.

Contributing to the literature, Chang and Yeh (2001) presented an objective approach to the evaluation of airline competitiveness. The evaluation problem was formulated as a multi-attribute decision-making model, which was solved by three widely used methods—the simple additive weighting method, the weighted product method, and the technique for order preference based on proximity to an ideal solution. This approach is based on multi-attribute value theory. A new empirical validation procedure was developed to mitigate the problem of inconsistency between the outcomes produced by the three methods. It conducted an empirical study on Taiwan's three major domestic airlines and addressed the advantage of the approach in assessing the results. The estimation found that the simple additive weighting method is superior among the three alternative methodologies.

Firms' heterogeneity and the way it is captured influence unbiasedness and consistency of the estimation results. Cliberto and Tamer (2009) applied the "probability function" methodology and empirically verified if a firm's heterogeneity has a significant impact on forming the market structure in the US airline industry. They uncovered evidence that airlines in their profit functions[6] are heterogeneous across the airlines. The competitive effects of large airlines—American, Delta, and United Airlines—showed a variance with those of low-cost carriers and Southwest Airline. Also, the competitive effect of an airline increased with its airport presence, which was taken into account in measuring the observable heterogeneity in the airline industry.

Johnston and Ozment analyze concentration in the US airline industry between 1970 and 2009. Concentration is proxied by the HHI (Herfindahl-Hirschman Index) and concentration ratio, along with variation in industry costs. The results showed an industry-wide trend of declining costs per available seat mile, which is negatively correlated with the increased level of output and concentration over the last thirty years. These findings support deregulation of the airline industry in the sense that they confirm presence of the sizable economies of scale; a major rationale for deregulation was a multitude of studies showing a lack of scale economies. The concentration ratios indicated that airlines would be behaving as an oligopoly. All measures of concentration show increased concentration ratios since deregulation, and the cost per unit of output has steadily decreased as output has increased. Somewhat inconsistent with this body of evidence, the price per unit of output has decreased even faster than costs.

In a recent study, Liang (2013) analyzed the quantitative effects of airport dominance on ticket prices by routes. The Hausman-Taylor method and random effects method were employed on data from the nine largest domestic US airlines in the third quarter of 1987 for service on 5428 routes. Liang argued that an airline's share of passengers on a route was positively linked with its ability to charge prices above costs. He also reasoned that the force of market concentration in the airline industry was unclear. Higher market concentration, reflected in the market share of the dominant carrier, showed that it was often linked to increases in the average market fare level. Another finding was that high concentration at an airport might

[6] Airline (%)/Airport presence/Cost (%)/Market level variables/Wright amendment/Dallas airport/Market size (population)/Per capita income/Income growth rate/Market distance (miles)/Closest airport (miles)/US centered distance (miles)/Number of markets.

Table 2.3 Testing for market concentration

Dependent variable	Average fare
Time varying exogenous variables	Fuel cost (labor cost was not included because it causes severe multi collinearity problem)
Time varying endogenous variables	Number of passengers, the largest carrier's market share on that route, the price difference between overall market fare and that charged by the largest carrier, the low fare carrier's market share, the price difference between market fare, the price charged by the low fare carrier
Time-invariant exogenous variables	Distance and hub

Source Liang (2013)

lead to more efficient operation and thus reduce the fare level. Variables used for the empirical test of this paper are listed in Table 2.3.

Clougherty (2009) investigated if the national-champion rationale fits with the airline industry's[7] performance. He produced a theoretical framework for analyzing the effect of domestic rivalry on the worldwide competitiveness of airlines by proposing three paths through which domestic rivalry can translate into enhanced international competitiveness. Data from 37 airlines across 19 nations over 1987–1992 (433 specific airline routes/total of 1889 observations) was empirically analyzed. Clougherty used an airline's international market share—i.e., share of revenue passengers in a particular international country-pair market—to measure its competitive performance. The study measured domestic market rivalry or domestic competition by the number of domestic competitors in the market where the airlines were based. Empirical analysis of the world airline industry showed that enhanced firm performance resulting from greater domestic rivalry is positively linked with improved international exports. The paper uses the following two approaches to compare the fitness and the efficiency of airlines (for details, see Table 2.4).

The results showed that domestic rivalry had a positive impact on international market shares. Both domestic network and the merger dummy variable were positively related to the international market share of airlines. International rivalry had a negative impact on market share, while an additional domestic competitor (i.e., domestic rivalry) led to an increase in an airline's market share. Clougherty (2009) confirmed that the result was consistent with Porter's (1990) idea that "International competition is not a substitute for domestic challenge".

Using a profit function approach, Okulski and Heshmati (2010) estimated profit maximization objectives of the US airlines using dynamic panel regression as suggested by Arellano and Bond (1991). He pointed out that first-order conditions can be derived from the profit functions and the competitive quantities of airline

[7]The author selected airlines for the test "because airline industry represents a good setting in which to consider the relationship between domestic rivalry and exports because of the ability to isolate the domestic-rivalry effects, the conformity of the airline industry to an idealized setting for the national-champion rationale, and the presence of joint economies of production".

Table 2.4 Approaches to compare estimation methods and model specifications

Methodology	Variables
Time and country specific fixed effect, LSDV	Lagged values of dependent variables, domestic-competitors, domestic-market-share, domestic-competitor-network, international rivalry, the merger dummy, home-competitors, and the airline's number of flights in the country-pair market
GMM	Two lagged dependent variables was included

Source Clougherty (2009)

seats, derived from Cournot and collusive structures, can be estimated. The conflict between these estimates and the actual seat capacities provided a measure of collusive behavior. In his second essay, conjectural variation parameters were estimated to assess the level of competition, which he then regressed on market conditions. The result demonstrated that airlines kept the quantity low to impose higher prices on some routes despite several challenges such as the issue of low-cost carriers, the 9/11 terrorist attacks, and the collusive behavior of airlines. The threat of entry, as measured by potential entrants, did not affect the probability of collusion on a route. Furthermore, he found no evidence that domestic code sharing necessarily leads to collusive behavior. The final essay explored the role of code sharing in the industry more comprehensively. It concluded that code sharing is a tool used by airlines to alleviate risk from uncertain demand and capacity constraints. Evidence from two difference-in-difference estimation studies revealed that code sharing leads to higher load factors and lower price dispersion, while the fares remained constant.

Several strategies positively influence the growth of different airline market participants. Adler and Gellman (2012) discussed strategies that would aid the airlines, airports, airframe, and engine manufacturers, and their first-tier suppliers as well as bodies governing the industry. They proposed that airlines need to employ strategies that can protect them from the risk of fuel price instability, the introduction of carbon cap, and trade regulations. They proposed a number of proactive strategies to ensure further industry growth in an economically, politically, and environmentally sustainable manner.

Price formation and level strongly influence the survival and profitability of airlines. Obermeyer et al. (2012) examined the effects of competition on price dispersion in the European airline markets. By conducting a cross-sectional analysis of 1200 flights between 130 European airport pairs, they confirmed that the characteristic of the European airline industry could be summarized as a non-monotonic link between competition intensity and price distribution. They connected the results of the paper with other studies on efficiency and productivity of airlines. Ticket price information on routes between the airports of European capitals and other international airports with more than one million departing passengers traveling within Europe in 2008 was collected for the analysis. Price dispersion for each flight was calculated on the basis of commonly used indices such as the Gini coefficient of inequality. The following variables listed in Table 2.5 were used for the empirical estimation of this study.

Table 2.5 Variables used in computation of Gini Coefficient

Variables	Definition
Flights	Variable that measures the number of flights on route during a fixed time interval. It is the capacity offered by all airlines operating on this route
LCC	Dummy variable indicating if a low-cost carrier is operating on route. It aims to capture the potential influence of low-cost carriers on competition
Tourist	Dummy variable indicating whether at least one of the cities on the route is a potential tourist destination. It intends to eliminate the potential influence of tourist traffic on price dispersion
Distance	A continuous variable that measures the distance between origin and destination airport, serving as a proxy for operating costs
Population	Average number of inhabitants in the metropolitan areas of the two end points on route. It was calculated as the arithmetic mean of passengers departed at the origin and destination airport on route
Airline fare	Control variable for systematic differences in price dispersion behavior between airlines

Source Obermeyer et al. (2012)

The results of this study confirmed the hypothesis that efficient airlines are better positioned to differentiate fares than their less efficient counterparts, providing empirical evidence of a non-monotonic relationship for the European airline market. The study also confirmed an inverse U-shaped association between the extent of competition and the scale of price dispersion for economy-class flights. Depending on the actual level of market concentration, an increase in competition can either increase or decrease the price dispersion.

Recently Cosmas et al. (2013) attempted to segment the US origin and destination (OD) markets into peer groups by performing statistical cluster analysis on OD city-pair data. The data was categorized by the market concentration, passenger volume, and yield. The study thoroughly reviewed the OD market structure, in much more detail compared to previous studies such as one by Belobaba and Van Acker (1994), which merely employed market concentration measured by the Herfindahl–Hirschman Index (HHI) or by the competitors' numbers to classify the market structures. The OD market clusters were defined using a two-step clustering process—first assigning cases to pre-clusters and subsequently grouping pre-clusters using a hierarchical clustering algorithm. The results showed that high-yield markets have, on average, consistently made the industry underperform in both passenger and revenue growth, whereas low-yield markets have led the industry in both areas.

2.4 Other Issues

The literature has focused on several other issues apart from the ones discussed above. Shan and Hamilton (1991) examined the hypothesis that land-specific advantage embedded in firms of a particular nationality is a motivation for

Table 2.6 Determinants of air travel demand

Oil gross domestic product	Exchange rate (Saudi Riyals/special drawing rights—SDR)
Private non-oil gross domestic product	Exchange rate (Saudi Riyals/US$)
Government non-oil gross domestic product	Population size
Total non-oil gross domestic product	Total expenditures
Total gross domestic product	Private consumption expenditures
Consumer price index	Total consumption expenditures
Per capita income	Yield
Import of goods and services	

Source Ba-Fail et al. (2000)

international inter-firm cooperation. A sample of domestic and international cooperative relationships formed by Japanese firms in the commercialization of biotechnology is applied to identify elements that differentiate domestic from foreign partners. The findings supported their hypothesis that country-specific advantage is a significant variable in explaining differences between cooperative relationships with partners of different countries.

In order to shed light on the issue of land-specific advantage, Ba-Fail et al. (2000) identified the components that influence the domestic air travel demand in Saudi Arabia. They built models for domestic air travel demand in the country with different combinations of explanatory variables, utilizing a stepwise regression technique. The model, which included total expenditures and population size as explanatory parameters, was proposed as the most suitable approach to embody the demand for domestic air travel in Saudi Arabia. The remaining models introduced in the paper were reported as suffering from a multicollinearity problem. The paper suggested implementing this model to specify and measure the relationship between domestic air travel demand and economic and demographic forces in the country. The following explanatory variables listed in Table 2.6 were selected to examine the relationship with air travel demand.

In focusing on the price and income responsiveness of consumers, Ferguson et al. (2007) looked into the specific issues of: (i) how does the role of price elasticity and cross-price elasticity improve previous models and (ii) how income elasticity improves market demand functions. They discussed the conditions for optimality using estimated market demand functions. Econometric modelling was applied to construct market demand functions. The role of multiple linear regressions improved the results on elasticity, cost degradation, and passenger diversion. The authors then built a model to optimize revenue generations for domestic flights.

Berry and Jia (2008) introduced a structural model of the airline industry and approximated the impact on profitability of demand and supply shocks caused by turbulence in the airline industry in the early 2000s. They revealed that the four major bankruptcies and two mergers, all involving legacy airlines, resulted in a large profit reduction. The study reported that the expansion of low-cost carriers

Table 2.7 Determinants of air and sea travel demands

Air travel demand	Number of airline passengers
Relative price	Fare ratio of air fare to sea fare levels
Relative frequency	Frequency ratio of the total number of flights to the total number of sea and ferry itineraries
Relative capacity	Seat ratio of the total number of aircraft seats to the total number of vessel seats
Relative time	Time ratio of the air travel times to the sea ferry travel times
Income GDP	Sum of the gross domestic product (GDP) of the origin zones and each destination island (in constant 1995 prices in million drachmas)
Tourism bed	Total number of visitor beds in hotels and other legal accommodation
Population POP	Product of the population size of the origin zones and of each destination island (in billions)

Source Tsekeris (2009)

(LCCs) significantly dented the legacy carriers' variable profits, and air-travel demand became more price-sensitive in 2006 compared to the late 1990s. Passengers showed a stronger preference for direct flights and the change in marginal cost favored direct flights. These factors, along with the expansion of LCCs, led to a more than 80 % reduction in the legacy carriers' profits. Along with escalating fuel costs and competition from LCCs, changes in demand patterns were also an important reason behind the legacy carriers' lower profits.

In another study on sensitivity and shifts in demand to fare changes, Tsekeris (2009) described a dynamic demand model, referred to as a dynamic abstract mode model, for estimating both short- and long-term responses of air passengers to relative changes in air and sea travel fares in competitive markets. The implementation of the model in the competitive market of Aegean islands in Greece showed that the volumes of air passengers and the relative travel costs explained current air travel demand to a significant degree (see Table 2.7).

Tourism has expanded dramatically in recent years. Assaker et al. (2011) applied structural equation modeling (SEM) methodologies to a cross-sectional data of 162 countries, evaluating the measurement and use of structural models on the relationship between the economy, society, environment, and tourism. Using SEM estimation, they examined the interconnection between the prime constituents of the tourism destination paradigm[8] and the demand for tourism at that destination. They found that although the economy construct had no direct influence on tourism, it did have a mediating positive impact on tourism through the society and environment constructs, with the society construct paralleling the condition of the infrastructure. Furthermore, society and environment were found to have a straight, positive influence on producing tourism undertakings and revenues. For a list of different categories of variables used in the specification of the models, see Table 2.8.

[8]The economy, society, and the natural and infrastructural environments.

Table 2.8 List of variable categories

Economic variables	Infra structure related variables	Society construction variables
Consumer price index (CPI); Purchasing power parity (PPP) Trade volume (TRADE) Foreign direct investment (FDI) Industry value added (IVA)	Road index (ROAD) Sanitation access (SAN) Electricity index (ELEC) Number of vehicles (AUTOS) Internet access (INT) Telephone mainlines (TEL) Mobile phones (CEL)	Education (EDU) Life expectancy (LEXP) Income (INC) Television index (TV) PC index (PC) Newspaper index (NEWS)

Source Assaker et al. (2011)

In 2012, IATA published a report on air travel demand entitled "Measuring the responsiveness of air travel demand to changes in prices and incomes." The report suggested various ways of measuring income and price elasticity on the basis of short-haul versus long-haul flights and by the regions. The report also presented various estimation methodologies.

The two-way or higher form of causality effects in airline studies reviewed above is not common. Koo et al. (2013) introduced a cause and effect structure into the relationship between tourism demand and air transport capacity. They then applied a vector error-correction model to assess whether capacity or passenger demand could be a significant cause for the return to long-run equilibrium following short-run deviations. Using data on international aviation between Australia, China, and Japan, they found that demand in the Japan–Australia market modifies for short-run nonconformities from the long-run equilibrium faster than the China–Australia market. The possible reasons for such variation in the adjustment speeds were discussed. The results were robust to the phenomenon of airlines preempting demand when setting capacity. In the short run, airline seats were generally static due to schedule commitments. Passenger demand, however, was responsive to economic conditions. The result suggested that the speed at which the equilibrium between supply and demand is reached is different for Japan and China.

Low-cost carriers (LCC) are seen as a source of changes in the airlines market. Pearson and Merkert (2014) examined whether LCCs are a critical danger to the sustainability of network airlines. The fast expansion of LCCs, particularly within the Asia-Pacific region, has impaired the growth of network airlines. The latter have responded to this phenomenon by forming lower-cost subsidiaries, identified as airlines-within-airlines (AWAs). The study attempted to delineate the criteria for successful AWAs and revise the analysis of past, present, and proposed and announced AWAs. With a thorough review of the previous studies, it found that AWAs have limited accomplishments, as 27 out of 67 AWAs failed, including three in the Asia-Pacific region. Of those presently operating, 58.1 % are from Asia Pacific, accounting for almost 40.0 % of the proposed and announced carriers. The study concludes that these AWAs are operating under ill-defined strategies, with rather late entrance into the market, excess management control from the parent airline which makes the AWAs very similar to the parent, higher costs and less efficiency vis-à-vis low-cost competitors. It concludes that operating AWAs with excess capacity and comparatively low fares in intensively competitive markets are the vital causes for failure. In contrast, the most successful AWAs have considerable independence from their parent, and have market dominance and decisive leadership. In this sense, they are not much different from the pure LCC model unless an ample revenue premium is realized.

In a recent study, Lowa et al. (2014) examines the performances of 114 major international airlines and 6 LCCs for the period between 1987 and 2010, using the resource-based theory. Results show that among the human, physical, and intangible resources at the aggregate industry level, intangible resources are the most critical factor behind performance success. Furthermore, the study noted that to become effective, airlines should provide satisfactory services at comparatively cheaper costs. Country-specific components such as the extent of liberalization—calculated by a bilateral open skies agreement between states—and the regions where airlines are located are important factors responsible for the higher profits made by some airlines and not others. The increasing consumer acceptance of new airlines indicates that established airlines cannot be complacent. Following the emergence of budget airlines that offer point-to-point service for short-distance destinations, full legacy carriers can distinguish themselves by providing direct services on long-distance flights.

2.5 The Conclusion

This chapter provides a review of studies, focusing mainly on the competitiveness of airlines. In our view, we have provided useful and up-to-date information on the modeling of airline efficiency, productivity, and competitiveness, and the results obtained. The review is classified into a wide variety of themes: efficiency, productivity, factor conditions; alliances and market liberalization; market concentration, market power, competition; and other issues such as price and income sensitivity of demand, tourism and the entry of low-cost airlines into the market. The review provides a comprehensive understanding of the literature. The information provided will be useful in influencing the specification of production and cost functions of airlines' operation in a manner that is consistent with both theory and practice. The review also serves as a guide to the best approaches in estimating airlines' efficiency through a comparative analysis of airlines with different characteristics. Finally, suitable policy recommendations have been provided on the basis of the results and the determinants of performance.

Appendix 2.1: Summary of Productivity and Efficiency Studies

Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Oum and Yu (1998)	Panel data	22 international airlines (1986–1993)	A translog variable cost function	Unit cost difference	Share of variable cost, Size, Output mix (RTK), Input prices—(labor, fuel, flight, equipment, ground property, equipment (GPE), and materials), Operating characteristics, Time effects	Maximum likelihood estimation	Capital input (negative) Stage length (negative) Efficiency (negative) Incidental (negative)
Oum et al. (2005)	Panel data	10 full-service carriers in Canada and US (1990–2001)	A multilateral index using the s translog function	Total factor productivity cost competitiveness, residual average yields	Output: RTKs Inputs: labor, fuel, materials, flight equipment, and ground property and equipment GPE, Output scale (size); Average stage length of flights; Composition of outputs (scheduled passenger services, scheduled freight services, non-scheduled services incidental services). Average load factor; Rate of fleet capacity, year dummy	Log-linear TFP regressions	Output size (positive) Average stage length (positive) Passenger load (positive) Fleet adjustment (negative) The year dummy (significant) Residual TFP and productive efficiency (the industry's average residual TFP decreased). Unit cost competitiveness (overall, the industry's average level of cost competitiveness was improved steadily from 1990 to 1997)

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(continued)

Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Barbot et al. (2008)	Cross-sectional data	49 intl. full-service airlines plus 10 LCC (2005)	Output/Input	Efficiency and TFP	Inputs: Labor, fleet fuel Outputs: ASKs, RPKs, RTKs	Data envelopment analysis and OLS	LCCs perform better than full-service airlines (DEA and TFP consistent) The majority of European and American carriers have higher effectiveness than Asia Pacific and China/North Asia airlines
Assaf et al. (2009)	Panel data	15 major UK airlines (2002–2007)		Efficiency	Output: TKA (ton kilometers available), total operational revenues, Inputs: labor expenses, aircraft fuel and oil expenses, load factor and airline size	DEA bootstrap methodology	The efficiency of UK airlines has continuously declined since 2004. Airline size and load factor were found to be significantly and positively related to technical efficiency variations. Factors such as increase in oil price and fierce market competition were also potential inefficiency determinants
Assaf (2009)	Panel data	of major 12 US airlines (2004–2007)	Cobb–Douglas production function	Input/output	Output: total operating revenues Inputs: Total operational cost (excluding labor cost), aircraft fuel and oil expenses, number of planes (proxy for capital input). Load factor (RPK/ASK)	Random effects (the Bayesian stochastic random frontier model)	Bayesian random stochastic frontier model fits data well with all coefficients correctly signed. Satisfy the theoretical requirements) The efficiency estimates: performance of US airlines has declined over time to reach a value of 69.02 % in 2007. Return to scale support the efficiency results. Confirmed that US airlines are not operating at an optimum level of scale

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Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Greer (2009)	Panel data	16 US airlines (1999–2008)		Efficiency	Inputs: labor, fuel and fleet-wide seating capacity. Output: ASK (available seat-miles). Union density, Average aircraft size, Average stage length, Degree of hubbing, Legacy carrier, Percent passengers-flying internationally	Data envelopment analysis and Tobit regression model	Due to the left- and right-censored variable problem of DEA, union density/aircraft size, (negative). Hubbing (influence a lot) unionized (exhibit lower levels of efficiency) Aircrafts age (not statistically significant). Result found that the more heavily unionized carriers are generally less efficient than the lesser unionized ones
Parast et al. (2010)	Panel data	US domestic airlines (network and low-cost carriers) (1989–2008)		Profitability	Quality and productivity; Passenger and ton-miles; Labor productivity; On-time performance; Gas price; Employee salary; Maintenance cost per flight hours; Passenger load factor	Correlation and multivariate regression analysis. Stepwise regression analysis	Labor productivity is the most significant predictor of profitability. On-time performance has no relationship with profitability. Labor productivity, gas price, average annual maintenance cost and employee salary are significant predictors of Profitability. The relationship between labor productivity and employee salary with profitability is positive. Gas price and average annual maintenance cost have a negative relationship with Profitability

(continued)

(continued)

Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Lee and Johnson (2011)	Panel data	5 US airline (2006–2008)	Profitability production function	Profitability efficiency and efficiency	Firm's fleet, Fuel expenses; Number of employees, scheduled revenue passenger miles (RPM); available seat miles (ASM); Production system: Capacity, design, demand generation, operations, demand consumption. Efficiency change: Efficiency was decomposed via a rational Network DEA model and decomposed into: Technical efficiency change, Scale efficiency change, allocative efficiency change	Two-dimensional efficiency decomposition (2DED) and OLS	Productivity was mainly caused by demand fluctuation than technical change in Production probabilities. The profitability efficiency in cargo service was 21 % more efficient than civil service. Capacity design significantly affect efficiency
Wang et al. (2013)	Cross-sectional data	30 airlines including 22 US carriers and 8 non-US (2006)		Output/input Technical efficiency	Input variables: Employees, Fuel expense, Aircraft. Output variables: ASMs, RPMs, Non-PAX Rev. Perfomance: Board size, Committees. Meetings, Non-executive director, CEO duality, CEO and chairman	Data envelopment analysis (DEA) and Multivariate analysis	More than half of US airlines less efficient than the best in the industry. performance of carriers is not just related to their characteristics such as the number of committees and non-executive directors But affected by the external factors
Merkert and Hensher (2011)	Panel data	58 of the largest passenger airlines		Output/Input Efficiency	Input: available tome kilometers (ATK) (proxy for capital), FTE (measure of labor).	Two-stage data envelopment analysis (DEA) with partially	Overall efficiency of the airlines has decreased over the two years. The relatively poor cost efficiency was a result of

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Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
		(2007/2008, 2008/2009)			Output: revenue passenger kilometers (RPK) and revenue ton kilomtres (RTK), Airline Size (ASK), Stage Length (km), Aircraft Size (seats), Fleet Age (years), Aircraft Families Aircraft Manufacturers	bootstrapped random effects regression	allocative inefficiency rather than of the technical inefficiency of the airlines
Cristina and Gramani (2012)	Panel data	4 airlines (2 Brazilian and 2 American) (1997–2006)		Operational performance and Financial performance	Inputs: Aircraft fuel, wages, salaries and Benefits, Cost per Available Seat Mile (CASM). Output: Revenue Passenger Mile 1/4 load factor, available seat mil, Input: 1/score, Efficiency, Outputs: flight revenue, Flight income	A two-step data envelopment analysis (DEA)	Emergent market, operational performance is always much better than the financial one, Resources optimization has been the main concern for these companies. Improving the operational efficiency does not necessarily generate an improvement in financial efficiency
Pires and Fernandes (2012)	Cross-sectional data	42 airlines from 25 countries (2001)	Catch-up effect (input-orientation) frontier-shift effect	Malmquist productivity index	Input: Financial leverage. Output: firm size, tangibility of assets, and intangible assets	Malmquist productivity analysis	Airlines which moved more aggressively to reduce their indebtedness showed improved profitability, for a given size, fleet and intangible assets. To expand their air transportation operations, airlines require substantial financial investments, especially in aircraft, fleet maintenance and information systems

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Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Powell II (2012)		US airline industry level data and the disaggregated carrier level data (1978–2009)		Productivity	Outputs: RPM (scheduled revenue passenger-miles), RTK (Scheduled, revenue ton-miles of freight), RMK (Scheduled revenue ton-miles of mail), Incidental revenue. Inputs: Labor, Fuel, Capital; Intermediate expense	MFP and TFP estimation	Despite of reduced productivity levels that coincide with exogenous shocks such as economic recessions, fuel price spikes, and other unforeseen events with negative impact, US passenger airlines experienced tremendous MFP improvements since deregulation
Merkert and Williams (2013)	Panel data	18 European Public service obligation (PSO) airlines (2007/08, 2008/09)	A semi-parametric approach	Technical efficiency	Inputs: available seat kilometers (ASK) and full-time equivalent (FTE), Outputs: revenue passenger kilometers (RPK) and realized departures 2nd stage Stage Length (km), PSO contracts, Duration (months), PSO_Share (in %), Ownership, year	Two-stage approach including DEA and truncated regressions	DEA models (VRS and CRS) the average bias-corrected technical efficiency scores are smaller than the average uncorrected scores Technical efficiency suggest that stage length has a negative impact on the operators' efficiency. Operators that are in an early stage of their contracts are more efficient than those that are close to the renewal/re-tendering of their contracts. That this impact is significant regardless of CRS or VRS assumption. Operators with a large number of PSO contracts to be more efficient than those with only a few contracts

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Author(s)	Type of data	Sample and period	Estimation structure	Dependant variable(s)	Independent variable(s)	Estimation method(s)	Findings/issues
Mallikarjun (2015)	27 US domestic airlines			Airline operating efficiency, cost efficiency, service effectiveness, Revenue Generation	Input: Operating expenses the first stage: ASM(available seat miles) is an output the 2nd stage: ASM is input revenue passenger miles (RPM) is output and Fleet size (FS) and destinations (DS) are the two site characteristics the 3rd stage: operating Revenue	The unoriented DEA network methodology	Major US airlines are more efficient than national US airlines in spending operating expenses and achieving operating revenue while not much significant difference in their service supply and demand efficiencies
Duygun et al. (2015)	Panel data	87 European airlines from 23 European countries (2000–2010)	A network Data Envelopment Analysis (network DEA) approach which comprises two sub-technologies	Efficiency	Inputs: Capital (flight capital)—number of aircrafts; Labor—Quantity of pilots, cabin crew, mechanics, passenger and aircraft handlers, and other labor (Divisia index); Materials Quantity of supplies, outside services, and non-flight equipment (Divisia index). Intermediate output: Revenue Ton Kilometers (RTK)/(LOAD FACTOR) Output: Revenue Ton Kilometers (RTK)	A network data envelopment analysis	In over all, most of the inefficiencies are produced in the first stage of the analysis. Most of the budget carriers' inefficiencies are restrained to the first stage. Performance of airlines are very dynamic and efficiency varied across types of airlines

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