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U.S. DOMESTIC AIRLINE FUEL EFFICIENCY RANKING, 2011–2012

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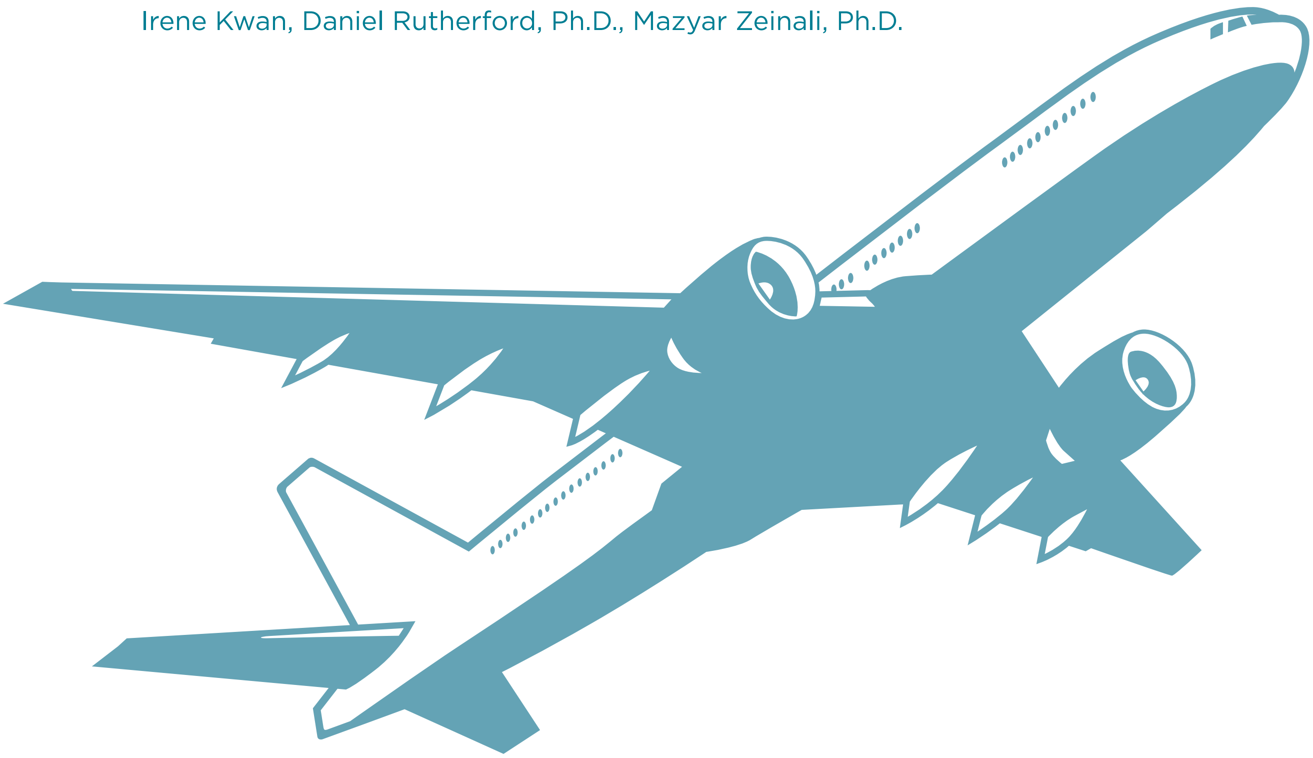

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EXECUTIVE SUMMARY

This report updates a 2013 study by the International Council on Clean Transportation (ICCT) that assessed the fuel efficiency of airlines serving the U.S. domestic market in 2010. This analysis uses primary airline-reported fuel burn and operations data to compare the fuel efficiency of major U.S. airlines on an apples-to-apples basis regardless of their size, network structure, and type of service, while also evaluating several drivers of in-use efficiency. With 2010 as a benchmark year, airline efficiencies can be tracked over subsequent years to observe relative changes. In 2012 the U.S. airline industry experienced particularly large changes due to two major mergers, United Airlines with Continental Airlines and Southwest Airlines with AirTran Airways.

Figure ES-1 summarizes the fuel efficiency scores (FES) of the 13 largest U.S. airlines on domestic operations in 2012. An FES of 1.00 corresponds to average in-use fuel efficiency in 2012, while values above or below 1.00 represent airlines that performed better or worse, respectively, than the industry average. Two industry-average fuel efficiencies are visible in the figure: 2012 (JetBlue Airways bar with FES equal to 1.00), and 2010, represented by the red dotted vertical line. Overall, the fuel efficiency of U.S. airlines in domestic operations improved by slightly more than 2% from 2010 to 2012, while the large fuel efficiency gap of 26% identified in the previous study has not closed.

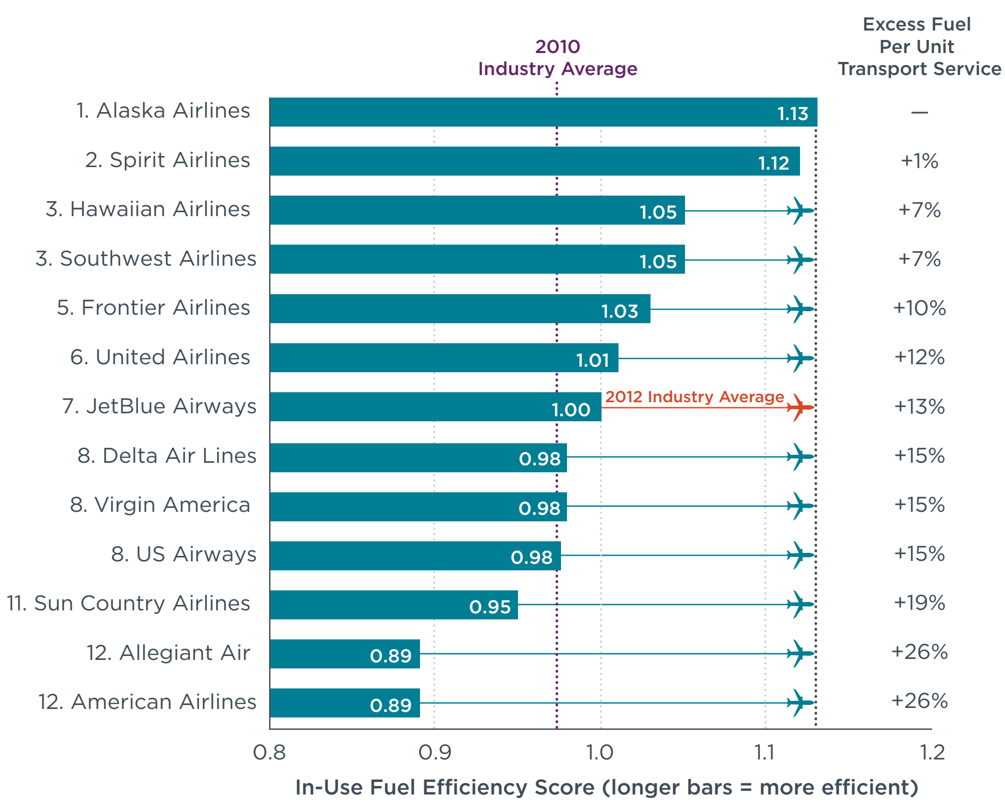

Figure ES-1. Fuel efficiency scores by airline for U.S. domestic operations in 2012

Alaska Airlines had the most efficient U.S. domestic operations in 2012, followed closely by Spirit Airlines, which burned roughly 1% more fuel than Alaska to provide a comparable level of transport service. Since 2010 Alaska and Spirit have widened their lead over other airlines through the adoption of advanced technologies and operational practices, respectively. Southwest and Hawaiian were tied for third in fuel efficiency in 2012, although each burn an estimated 7% more fuel than Alaska on equivalent operations. Frontier Airlines was the fifth most fuel-efficient domestic carrier in 2012, followed by United Airlines in sixth, which became the most fuel-efficient full-service U.S. carrier following its merger with Continental Airlines. As noted above, JetBlue Airways represents the industry average fuel efficiency for 2012, burning approximately 13% more fuel per unit transport service than Alaska that year.

The remaining airlines in Figure ES-1 had fuel efficiencies below the 2012 industry average. Virgin America, Delta Air Lines, and US Airways were tied as the eighth most fuel-efficient carrier, although they burned approximately 15% more fuel per unit transport service than the leader, Alaska. Sun Country Airlines followed in eleventh place with an FES of 0.95, while Allegiant Air and American Airlines tied as the two least fuel-efficient carriers with FES scores of 0.89, or 26% less efficient than Alaska in 2012.

Table ES-1 presents the relative fuel efficiency rankings for 2010 to 2012, highlighting the relative shifts in ranking from year to year. Due to the United-Continental and Southwest-AirTran mergers, the total number of airlines surveyed dropped from 15 in 2010 to 13 in 2012.

Table ES-1. Airline fuel efficiency rankings for U.S. domestic operations, 2010–2012

Rank	2010	2011	2012
1	Alaska	Alaska	Alaska
2	**Spirit***	Spirit	Spirit
3	**Hawaiian***	**Southwest***	**Southwest***
4	Continental	**Hawaiian***	**Hawaiian***
5	Southwest	Frontier	Frontier
6	Frontier	Continental	United
7	JetBlue	JetBlue	JetBlue
8	United	United	**Virgin***
9	Virgin	Delta	**Delta***
10	Sun Country	**Sun Country***	**US Airways***
11	Delta	**US Airways***	Sun Country
12	US Airways	**Virgin***	**Allegiant***
13	AirTran	AirTran	**American***
14	American	American	–
15	Allegiant	Allegiant	–

*** Denotes ties between airlines in a given year.**

As indicated in Table ES-1, Alaska remained the most fuel-efficient U.S. domestic carrier from 2010 to 2012, followed closely by Spirit. Southwest, ranked fifth in 2010, jumped to a tie for third with Hawaiian due to large efficiency gains in 2011. Notably, Southwest remained tied with Hawaiian in fuel efficiency terms after its 2012 merger, due to strategic choices in favor of fuel efficiency after merging with the smaller, much less efficient AirTran Airways (thirteenth in both 2010 and 2011). In contrast, United moved from eighth most fuel-efficient carrier in 2010 (industry average) to sixth (1% above industry average) in 2012 following its merger with Continental, with a 2012 FES (1.01, in Figure ES-1) that was lower than what would have been expected given the efficiency of the parent airlines and their relative sizes. Although not completely clear, this outcome may be attributable to changes in Continental's operations mid-merger, including the poor fuel performance of one of its regional affiliates along with merger issues causing flight delays that increased fuel consumption.

Among the airlines with below-average fuel efficiencies, Virgin America showed the largest relative shift in rankings over the past three years, falling from ninth (2010) to eleventh (2011) before improving to eighth (2012). Rapid growth in Virgin's fleet and operations during this period may explain these shifts. While American and Allegiant remained the two least efficient U.S. carriers throughout this survey, Allegiant gained ground due to the expanded use of relatively newer, more efficient Boeing 757 aircraft (compared to its older MD-80s) in 2012.

An analysis of aircraft technology and operations, including the effect of mergers and airlines' business strategies, provides some insight into these fuel efficiency differences. In addition to the rankings themselves, several higher-level conclusions can be drawn:

1. Technology has a strong impact on the relative efficiency of various airlines. The best-performing airlines flew newer, more efficient aircraft, while the least-efficient carriers flew older models with excess fuel burn.
2. That being said, airlines can utilize the same aircraft types in more or less efficient ways. An airline's operational practices significantly influence how efficiently it operates a given aircraft type.
3. The fuel efficiency gap between the most and least efficient airlines identified in 2010 (26%) is not closing.
4. Recent mergers have impacted airline fuel efficiency in different ways. While one combined airline (Southwest) maintained and even improved its fuel efficiency during the merger, another (United) had lower-than-expected post-merger fuel efficiency on its U.S. domestic operations.
5. The link between airline efficiency and profitability remains complex. Some airlines are able to reap profits even with, or because of, their fuel-intensive business models.

Looking forward, policymakers, the business community, and the traveling public are increasingly demanding better information on airline fuel efficiency to inform their policy, investment, and purchasing decisions. For this reason, this analysis will be updated with 2013 results once the full year of U.S. Department of Transportation data has been made available, processed, and analyzed. That additional data should provide further insight into how U.S. domestic airline efficiency has changed since 2010 for use by interested parties.

1. INTRODUCTION

There is an increasing awareness about the environmental impact of air travel. In 2006, aviation emissions were estimated to account for 2.5% of anthropogenic carbon dioxide (CO_2) emissions and up to 5% of historical radiative forcing, including aviation-induced cloudiness (Lee et al., 2009). Since 1960, there has been a 400% growth in global aviation CO_2 emissions, which are projected to quadruple again by 2050 to 2.5 billion tonnes CO_2 under business-as-usual scenarios (ICAO, 2011). The combination of efficiency gains in other modes and the growth in aviation demand could more than triple aviation's relative contribution to anthropogenic CO_2 if present trends continue.

Until recently, there has been surprisingly little public information about airline fuel efficiency available to policymakers, investors, and consumers. Information about how airlines can operate their aircraft more efficiently could be used to craft policies to reward more efficient airlines while promoting practices that reduce fuel consumption. Since fuel price drives a large share of operational costs, investors could use information about fuel efficiency to make better investment decisions. Finally, business and leisure travelers with access to information on airline fuel efficiency could use it to select less carbon-intensive travel options.

In particular, policymakers and industry have begun discussing ways to constrain emissions growth. The International Civil Aviation Organization (ICAO), the de facto regulator of airlines worldwide, is currently developing standards and guidelines to improve the environmental performance of aviation (ICAO, 2014). Simultaneously, the U.S. Environmental Protection Agency has declared its intention to determine whether greenhouse gas emissions from aircraft endanger human health and welfare and therefore should be regulated under the Clean Air Act (Center for Biological Diversity, 2011). Meanwhile, industry, including aircraft manufacturers and airlines, are making strides to reduce their contribution to the aviation sector's carbon footprint with the aim to achieve carbon-neutral growth in 2020. A number of other parameters largely under the control of airlines — aircraft utilization, flying speed, fuel-loading practices, passenger load factor, and ground time, among others — influence in-use efficiency and fuel consumption.

In September 2013, the International Council on Clean Transportation (ICCT) released a report comparing the fuel efficiency of the fifteen largest U.S. airlines on U.S. domestic operations in 2010 (Zeinali, Rutherford, Kwan, & Kharina, 2013). That study, applying a methodology developed by researchers at the University of California, Berkeley, National Center of Excellence for Aviation Operations Research (Zou, Hansen, & Elke, 2012), revealed a 26% gap between the most (Alaska) and least (Allegiant) fuel-efficient carriers in 2010. The work presented here updates the 2010 airline fuel efficiency ranking based upon 2011 and 2012 operations. This approach enables an apples-to-apples comparison of airline efficiency by controlling for differences in business models across carriers, as described below.

The 2013 study established 2010 as a benchmark year off of which future efficiency improvements could be tracked over time. This update, which presents comparable results for 2011 and 2012, provides a closer look at various efficiency parameters that can help describe changes in the relative efficiency of airlines over time. In addition, 2012 saw significant changes in the industry due to two major mergers, Southwest Airlines (merged with AirTran Airways) and United Airlines (merged with Continental Airlines). This report sheds light on the short-term effect of those mergers on in-use fuel efficiency.

2. METHODOLOGY

This update applies the methodology developed in collaboration with NEXTOR researchers at the University of California, Berkeley, to evaluate and compare the fuel efficiency of U.S. airlines on domestic routes. Quarterly reported traffic and fuel data provided by Data Base Products, a reseller of Form 41 U.S. air carrier data from the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS), is used to develop a statistical model normalizing each airline's fuel consumption by the transport service it provides.[1] The frontier model approach (Kumbhakar & Knox Lovell, 2000) uses the best-performing airline(s) to benchmark the fuel efficiency of less efficient airlines based upon both the revenue passenger miles (measure of mobility) and departures (measure of access) they provide. The model form is shown below in Equation 1, relating the input, fuel, of an airline *i* at time *t* to its output, revenue passenger miles (RPM)[2] and departures (dep):

$$fuel_{it} = f\,(RPM_{it},\, dep_{it}) + \eta_{it} \qquad \textbf{[Eq. 1]}$$

where η_{it} represents the airline's true inefficiency.[3]

The previous 2010 study's assignment of regional affiliates to their mainline airlines[4] was refined for this update. Data was obtained from the Airline Origin and Destination Survey (DB1B), a 10 percent sample of airline tickets from reporting carriers, which provides ticket-specific information on marketing and operating carrier, origin and destination airport, intermediate airport(s), passenger count, and itinerary distance, among others.[5] Using the data, all regional affiliates to mainline airlines were identified. Information on the total RPMs flown by all affiliates for each mainline was used to determine an RPM percentage breakdown. RPMs flown by each regional affiliate were assigned to its mainline carrier(s) by applying the percentage breakdown to the regional affiliates' actual reported RPM values. Final results for the 2011 and 2012 regional affiliate RPM assignments are shown in Appendix C.

The affiliate departures and fuel assigned to mainline carriers were assumed to be proportional to the RPMs assigned. In cases where regional affiliates did not report their fuel, a regression model similar to that of the frontier model relating fuel burn to RPMs and departures was used to estimate missing values. RPM and departure values are obtained from BTS T100 flight segment data[6] and used in the regression model to estimate the corresponding fuel value for each missing quarter. New quarterly RPM, fuel, and departure values for each of the mainline carriers were determined by adding the sum of the RPM, fuel, and departure contributions of their respective regional affiliate(s).

A unitless fuel efficiency score (FES) is calculated by normalizing each airline's inefficiency value by the simple average across all airlines. A higher FES indicates relatively higher fuel efficiency. Thus, airlines with an FES greater than 1.00 are more efficient

1 U.S. Department of Transportation, BTS Form 41 Financial Data (2014).

2 Revenue passenger miles, or RPMs, denotes the product of the total passengers served by an airline times their distance traveled. RPMs can also be calculated as available seat miles times the load factor (% of seats filled) for either a given flight or for an airline over its entire operations.

3 Additional detail regarding the methodology can be found in Appendix A of this report.

4 The 2010 analysis tracked the segment-level affiliation information through airlines' websites, route map, and other online resources in a later year (early 2012).

5 U.S. Department of Transportation, BTS Airline Origin and Destination Survey (DB1B) (2014).

6 U.S. Department of Transportation, BTS Form 41 Traffic (2014).

(consume less fuel per unit of transport service than the industry average), while scores below 1.00 are less efficient.

This approach enables an equitable comparison of airline fuel efficiency for four reasons. First, it uses primary fuel data rather than modeled estimates, thus crediting airlines for the full range of actions they can take to reduce fuel use.[7] Second, the FES metric compares the efficiency of airlines operating diverse business models (i.e., different combinations of mobility and access) on an apples-to-apples basis, while simplified metrics, such as fuel consumed per passenger mile, are biased in favor of airlines operating fewer, longer flights. Third, this approach includes regional affiliates, which provide passenger air service from smaller airports to the larger network of mainline carriers. Regional affiliates, which can fly more than 20% of an airline's total RPMs, are counted as part of a mainline carrier's operations. Together, the mainline carriers and their affiliates make up more than 99.5% of the total U.S. domestic RPMs. Finally, this approach rewards airlines for operating more direct routes as opposed to those flying circuitous itineraries where passengers must fly longer distances between their origin and intended destination.

7 Analyses based upon modeled, rather than reported, fuel consumption data are only able to credit airlines for actions to improve fuel efficiency that are reflected in the available input data. Thus, while strategies such as utilizing new aircraft and flying with higher load factors will be rewarded, other approaches, such as aircraft lightweighting, optimized cruise speeds and flight paths, and single engine taxi, will not, as these parameters are not reported to BTS. In contrast, a metric developed via reported fuel data will credit all of these strategies.

3. RESULTS

This section summarizes the key findings of this study, and investigates why particular airlines are more or less efficient. Additionally, other findings, including how the efficiency of U.S. airlines as a whole has changed since 2010, the impact of mergers on fuel efficiency, and the relationship between airline profitability and fuel use, are discussed.

3.1 AIRLINE FUEL EFFICIENCY SCORES AND RANKING

Figure 1 summarizes each airline's FES for U.S. operations in 2012 (see Appendix B for 2011 results). The FES measures the relative transport service (combination of mobility and access) provided per unit of fuel consumed, normalized by the average fuel efficiency of all airlines in the study. As noted above, airlines with scores greater than 1.00 are more efficient (consume less fuel per unit of transport service) than the industry average, while scores below 1.00 indicate airlines than are less efficient than their average peer. Since fuel consumption is inversely related to efficiency, the fuel consumption, and therefore CO_2 emissions, of each airline for a comparable level of transport service is inversely related to its FES. The rightmost values in Figure 1 summarize excess fuel burn relative to the most efficient airline in this survey (Alaska).

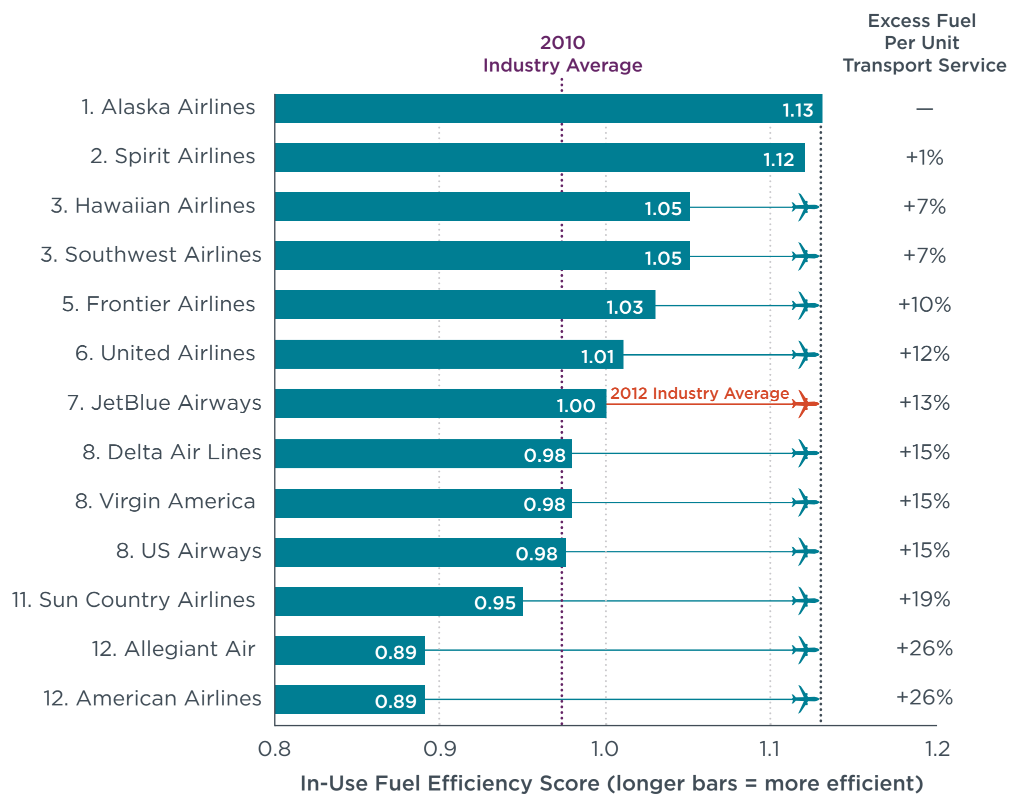

Figure 1. Fuel efficiency scores by airline for U.S. domestic operations in 2012

Alaska Airlines, a legacy carrier based on the West Coast, had the most fuel-efficient U.S. domestic operations in 2012, followed closely by Spirit Airlines, which burned roughly 1% more fuel than Alaska to provide a comparable level of transport service. Since 2010 Alaska and Spirit have widened their lead over other airlines through the adoption of advanced technologies and operational practices, respectively (see Section 3.2). Southwest Airlines, the world's largest low-cost carrier (in terms of passengers carried domestically), tied with Hawaiian Airlines for third in fuel efficiency in 2012, although both airlines burned a full 7% more fuel on equivalent operations compared to Alaska. Frontier Airlines, a low-cost carrier based in Denver, Colorado, was the fifth most fuel-efficient domestic carrier in 2012, followed by United Airlines in sixth. United became the most efficient full-service U.S. carrier following its merger with Continental Airlines in 2012. JetBlue Airways demonstrated fuel efficiency equal to the U.S. domestic average in both 2011 and 2012.

The remaining airlines in Figure 1 had below-average fuel efficiencies in 2012. Virgin America, Delta, and US Airways were tied for eighth position, burning approximately 15% more fuel per unit of transport service than Alaska. Virgin America is a relatively young carrier that came into service in 2007, specializing in longer coast-to-coast flights. Delta Airlines, which completed its merger with Northwest Airlines in 2010, was the largest U.S. domestic airline until United Airlines received a single operating certificate from the Federal Aviation Administration on November 20, 2011, finalizing its merger with Continental Airlines. Sun Country followed in eleventh place with an FES of 0.95, while Allegiant Air and American Airlines tied as the two least fuel-efficient carriers in this survey, burning 26% more fuel than Alaska on equivalent operations in 2012.

Two industry-average fuel efficiencies are visible in Figure 1: 2012 (JetBlue Airways bar with FES equal to 1.00) and 2010, represented by the purple dotted vertical line. Overall, the fuel efficiency of U.S. domestic operations improved by approximately 2.3% (Table 4) between 2010 and 2012 due to fleet turnover and improved operational practices, including improving load factors.

Table 1 shows the airlines' relative rankings in the three years studied. Due to mergers, the total number of airlines fell from 15 in 2010 to 13 in 2012.

Table 1. Airline fuel efficiency rankings for U.S. domestic operations, 2010–2012

Rank	2010	2011	2012
1	Alaska	Alaska	Alaska
2	**Spirit***	Spirit	Spirit
3	**Hawaiian***	**Southwest***	**Southwest***
4	Continental	**Hawaiian***	**Hawaiian***
5	Southwest	Frontier	Frontier
6	Frontier	Continental →	United
7	JetBlue	JetBlue	JetBlue
8	United	United	**Virgin***
9	Virgin	Delta	**Delta***
10	Sun Country	**Sun Country***	**US Airways***
11	Delta	**US Airways***	Sun Country
12	US Airways	**Virgin***	**Allegiant***
13	AirTran	AirTran	**American***
14	American	American	–
15	Allegiant	Allegiant	–

*** Denotes ties between airlines in a given year.**

Alaska was the most fuel-efficient U.S. domestic carrier from 2010 to 2012, followed closely by Spirit. Southwest, ranked fifth in 2010, improved its standing substantially in 2011 and tied for third with Hawaiian, a position it retained even after its 2012 merger with much less efficient AirTran Airways. Frontier improved in the rankings due to strong efficiency improvements in 2011 because of improved operational practices and the utilization of more efficient aircraft (see Appendix B). As previously noted, United's domestic operations moved from eighth most efficient in 2010 (industry average) to sixth in 2012 (1% better than industry average) following its merger with the more efficient Continental. JetBlue, ranked seventh in all three years of the study, was the industry average airline in both 2011 and 2012.

Airlines ranking in the middle retained similar positions with the exception of Virgin America, which showed the largest shift in relative efficiency over the past three years, falling from ninth (2010) to eleventh (2011) before improving to eighth (2012). Rapid growth in its fleet and operations (21% increase in the number of flights from 2010 to 2011 and another 25% from 2011 to 2012) may help explain these shifts. Virgin added 12 Airbus A320 aircraft to its fleet in 2011 and 12 more in 2012, and is flying an increasing share of RPMs on A320s, which are more fuel-efficient than the "shrink" A319 version on an RPM per fuel weight basis, over time (see Tables 2 and 3 below). At the aircraft type level, the in-use efficiency of Virgin's A320 and A319 improved in 2012 as indicated by the transport service they provided relative to their fuel consumption, although the precise drivers of this improvement cannot be identified from available data. American and Allegiant remained the two least fuel-efficient U.S. carriers throughout this survey, although Allegiant improved its performance in 2012 due to its expanded use of relatively newer, more efficient Boeing 757 aircraft (compared to its older McDonnell Douglas MD-80s).

3.2 OTHER FINDINGS

The following trends were identified in addition to these findings.

Technology has a strong impact on the relative efficiency of various airlines

A great disparity in aircraft age and fuel efficiency underlies the airline efficiency gap. Alaska continues to make efficiency improvements via the increased use of its newer, efficient Boeing 737-800s (Figure 2a). In contrast, Allegiant relies upon older and less efficient MD-80s for over 90% of its RPMs flown (Figure 2b). The average age of aircraft in Alaska's fleet was only 7 years, compared to about 23 years for Allegiant. One issue to track in future years will be Allegiant's expanded use of its Boeing 757-200 aircraft on routes to Hawaii.[8]

8 In March 2010, Allegiant signed an agreement to acquire six Boeing 757-200 aircraft as part of its plans to expand into Hawaii (Ranson, 2010). Beginning in July 2013, Allegiant provided new nonstop jet service from Los Angeles to Honolulu (Allegiant Air, 2013).

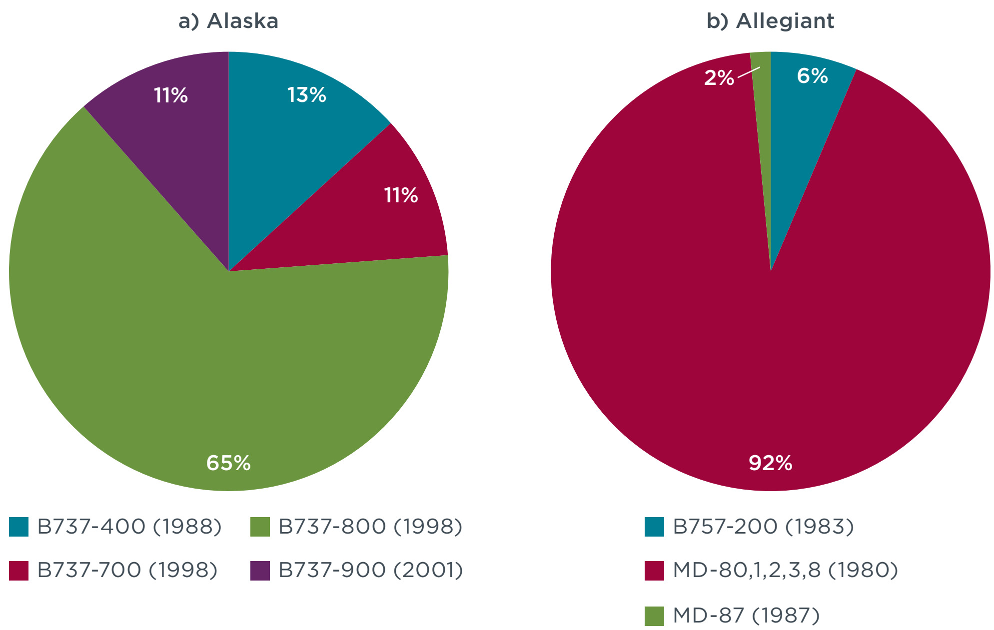

Figure 2. Revenue passenger miles by aircraft type (entry into service date) for (a) Alaska and (b) Allegiant in 2012

Alaska's high FES is attributable partially to its main affiliate Horizon Air, which in 2012 completely phased out its fuel-intensive Canadair CRJ-700 regional jets in favor of more efficient Bombardier Dash 8-Q400 turboprops (Figure 3). On a single flight with trip length 500 miles and 80% passenger load factor, the Dash 8-Q400 is about 22% more efficient than the CRJ-700 on a passenger mile per fuel basis.[9]

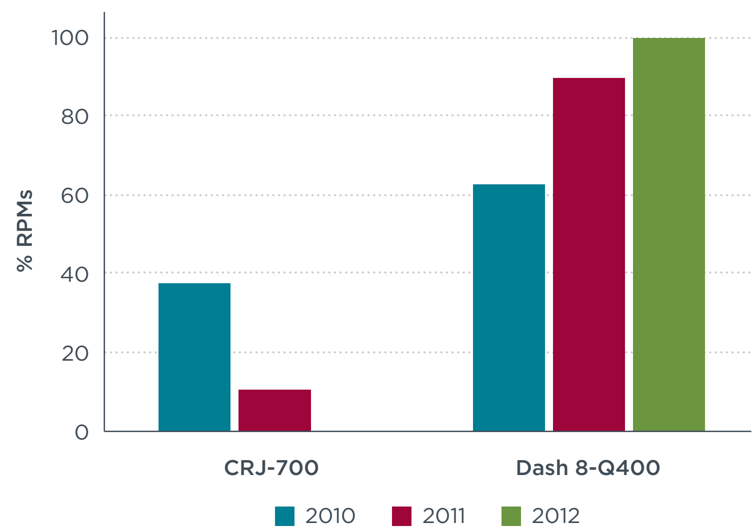

Figure 3. Horizon revenue passenger miles by aircraft type, 2010–2012

Aircraft choice by affiliate airlines clearly affects mainline airline fuel efficiency. The affiliates of many large carriers, such as American, continue to use regional jets extensively.

9 Aircraft fuel burn was modeled using Piano-X, an aircraft emissions and performance model developed and distributed by Lissys, a British analytical software firm. See http://www.lissys.demon.co.uk/

For example, Horizon flew 7% of Alaska's RPMs with turboprops (Dash 8-Q400), while American Eagle provided 11% of American's RPMs, all with regional jets (CRJ-700 and Embraer 140/145). The choice of aircraft — even among a mainline's regional affiliates — can make a large difference in overall airline efficiency. If Horizon Air were excluded from the analysis, Alaska's 2012 FES would fall below Spirit's. Conversely, if Spirit had identical affiliate operations to Alaska in 2012, it would be the most efficient airline by approximately 1%. Were Spirit and other airlines able to integrate turboprops into their operations, their fuel efficiencies could increase significantly.[10]

Airlines can utilize the same aircraft in more or less efficient ways

Aside from aircraft choice, the way in which an airline uses a given aircraft also influences its in-use efficiency. Consider the case of Spirit Airlines, which operates its A319 and A320 aircraft very efficiently compared to other carriers (Tables 2 and 3).

Table 2. Airline efficiency on the A320 in 2012

Carrier	Efficiency (passenger miles/lb fuel)	Difference from top performer	Average seat count	Average load factor	Average fleet age
Spirit	13.0	--	178	85%	0.9
Frontier	10.4	-20%	166	91%	3.8
Virgin	10.0	-23%	148	79%	3.1
JetBlue	9.3	-28%	150	84%	7.0
US Airways	9.1	-30%	150	87%	13.5
Delta	8.9	-32%	150	83%	17.3
United	8.6	-34%	142	85%	14.1

Source: Data Base Products (2014); Ascend Online Fleets (2014)

Table 3. Airline efficiency on the A319 in 2012

Carrier	Efficiency (passenger miles/lb fuel)	Difference from top performer	Average seat count	Average load factor	Average fleet age
Spirit	9.0	--	145	87%	6.1
Frontier	9.0	--	138	89%	8.0
Virgin	8.9	-1%	119	82%	4.8
United	7.6	-16%	120	84%	12.4
US Airways	7.3	-19%	124	80%	10.4
Delta	6.8	-24%	124	83%	6.1

Source: Data Base Products (2014); Ascend Online Fleets (2014)

10 Note that turboprop aircraft are typically flown for smaller, shorter-range flights. The RPM-weighted average seat count and flight length for turboprop aircraft for U.S. domestic operations was 57 seats and about 240 miles (great circle distance), respectively, in 2012 (Data Base Products, 2014).

Spirit is up to 34% more efficient than its competitors on a passenger mile per fuel basis using the same aircraft types, due in part to higher seating densities and load factor, which in combination means that an A320 flight on Spirit may transport 20 to 30 more passengers than a similar aircraft flown by its rivals. Other drivers of Spirit's in-use efficiency may include lighter furnishings, reduced baggage load due to its fee structure, and, more speculatively, flying slower and with a reduced fuel load.[11] Spirit's Airbus fleet is also among the youngest for U.S. domestic operations.

The efficiency gap between the most- and least-efficient airlines is not closing

The results presented here describe the overall fuel efficiency of airlines serving the U.S. domestic market. Given that fuel accounts for about a third of airline operating costs and fuel prices have remained consistently high in the time period studied, one might expect that the gap in fuel efficiency between the top and bottom performers identified in 2010 would be closing. In fact, the gap between the top performer, Alaska, and the worst performer, Allegiant, actually widened to 30% in 2011 before returning to 26% in 2012 (Table 4).

Table 4. Trends in overall U.S. domestic airline fuel efficiency, 2010–2012

Year	Maximum variation in fuel consumption per unit transport service	Average system fuel efficiency improvement from 2010*
2010	26%	--
2011	30%	+1.2%
2012	26%	+2.3%

* Calculated based on how all carriers performed collectively according to the transport service metric, using 2010 frontier coefficients.

Alaska and its affiliate Horizon operate an increasingly fuel-efficient fleet consisting primarily of Boeing 737-800s and Dash 8s. Allegiant, on the other hand, continues to rely heavily on older, much less efficient MD-80s. However, Allegiant did introduce relatively more efficient aircraft, second-hand Boeing 757-200 aircraft (averaging 19 years old) into its fleet. Two percent of its total RPMs were flown on this new aircraft type in 2011, increasing to six percent in 2012.

Recent mergers have impacted airline fuel efficiency in different ways

The two major mergers in 2012 — United-Continental and Southwest-AirTran — provide an opportunity to investigate the short-term effect of mergers on airline fuel efficiency. The data available here suggest that the influence of mergers on airline efficiency varies from case to case, with one combined carrier (Southwest-AirTran) continuing to improve in efficiency terms following the merger, and the other (United-Continental) ending up with a lower FES (1.01, in Figure 1) than would have been expected given the 2010 efficiency of the parent airlines and their relative sizes. This difference may be related to the differing size of the airlines involved: Southwest merged with an airline only about 20% of its operational size (in terms of RPMs), while United merged with one almost 80% of its operational size.

11 Flying slower near the maximum fuel efficiency of an aircraft (100% maximum specific air range) can reduce fuel burn relative to flying at faster speeds. Fuel loading procedures to determine the amount of fuel to be loaded for a given flight can vary by airlines, with some airlines loading more fuel than required (known as tankering) in order to reduce turnaround time at the flight's next stop. This results in a heavier aircraft, which in turn causes additional fuel burn.

Two key factors may explain Southwest's strong fuel efficiency performance. The first is aircraft choice, with Southwest phasing out older Boeing 737-300 and 737-500 aircraft in favor of newer 737-700 aircraft and then 737-800 aircraft beginning in 2012 (Figure 4). Furthermore, Southwest made strategic choices in favor of fuel efficiency upon merging with a much less efficient partner airline. Southwest acquired 88 Boeing 717-200s and 52 Boeing 737-700s from AirTran, while adding 34 Boeing 737-800s to its fleet.[12] In 2012, Southwest decided against adding a second aircraft type to its Boeing 737 fleet by selling all of its less-efficient Boeing 717s to Delta (Mutzabaugh, 2013), enabling it to streamline operations and to minimize extra expenses due to training, maintenance, and operations (Trejos, 2012). The second factor may be Southwest's fuel costs, which increased 25% in 2011 due to fuel price hedges that locked in higher prices even as those for competing carriers moderated. This sudden spike in fuel price for Southwest may have provoked changes in operational practices to save fuel.[13]

Figure 4. Revenue passenger miles by aircraft types for (a) Southwest and (b) AirTran, 2010–2012

The United-Continental merger provides the opposite case, with the fuel efficiency of the combined carrier being lower than that of the weighted average of its parent carriers in 2010. Several factors may be at work. Continental's fuel efficiency fell noticeably mid-

12 In contrast, United acquired over 300 aircraft from Continental and added multiple new types to its domestic fleet, including the Boeing 737-500, -700, -800, and -900; the Boeing 757-300, 767-200, and 767-400 aircraft which it continues to maintain today.

13 Southwest has adapted to rising fuel costs since 2011 via fleet modernization plans, including the purchase of more fuel-efficient Boeing 737-800 and 737-700 aircraft to replace its less fuel-efficient Classic fleet (Southwest Airlines, 2011).

merger (see Table 1 above and Appendix B) for reasons that are not completely clear. Continental's falling efficiency in 2011 may be attributable to a 1.4% decrease in average passenger load factor and to the poor performance of its regional affiliate.[14] Flight delays due to difficulties in integrating the two airlines' flight management and scheduling systems may have also impacted fuel efficiency of the combined airline (Johnsson & Schlangenstein, 2014). Notably, United's average on-time performance, measured as a percentage of flights that arrived within 15 minutes of scheduled arrival time, decreased from 85% in 2010 to 80% in 2011 to 77% in 2012.[15]

Collectively, these differing experiences suggest that the short-term effect of airline mergers on efficiency may vary on a case-by-case basis. Additional years of data for these two airlines, as well as for the upcoming American-US Airways merger, may provide additional clarity on this issue.

The link between fuel efficiency and profitability remains complex

The 2010 efficiency ranking discovered a poor correlation between fuel efficiency and airline profitability. Jones (2013) notes that the airline industry is on a "profitable path" and has become better at "putting the planes where the demand is." That is, they are matching the aircraft to the route based on the number of aircraft seats and passenger demand, whereas matching an aircraft to its optimum operating range and fuel efficiency is not as much a priority. Figure 5 plots each airline's 2012 FES versus its profit margin on U.S. domestic operations from 2010 to 2012.

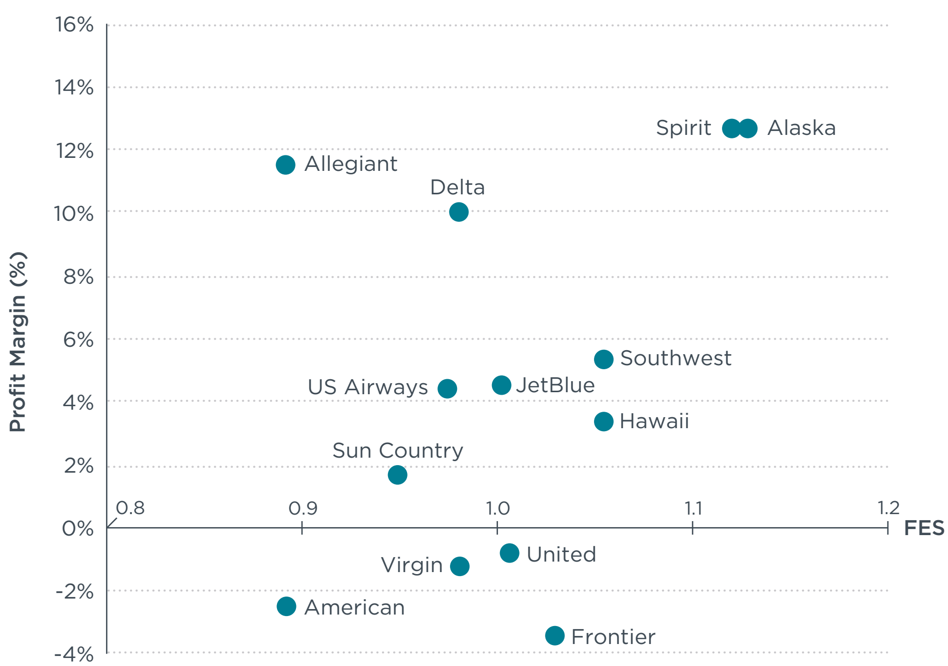

Figure 5. Net operating profit margin (2010-2012) and 2012 FES, mainline airlines

14 The reported in-use efficiency of ExpressJet, Continental's largest regional affiliate — providing almost 60% of Continental's affiliate-flown RPMs and over 10% of total RPMs — fell noticeably in 2011. Although ExpressJet flights increased by 4% in 2011 (some being new flight routes flown for Continental), its fuel burn increased by 16%.

15 U.S. Department of Transportation, BTS Airline On-Time Performance Data (2014).

As before, the relationship between profitability and efficiency remains complex. Efficient Alaska was the most profitable airline over this period, followed by Spirit, the second most efficient domestic airline. Spirit's flights are packed throughout the day, with aircraft having more seats than those of other airlines. Furthermore, in 2011 Spirit earned 36% of its revenue from ancillary charges such as passenger checked bags, larger carry-on bags, ticket change, and ticket cancellations.[16] The third most profitable airline was Allegiant, which continues to fly MD-80s aircraft with very low upfront costs on direct flights with very high passenger load factors (averaging 90%).

The fourth most profitable airline on domestic operations was Delta Air Lines. Delta anticipated all-time record profits in 2013 as its passenger traffic and average fare increased (Jones & Mutzabaugh, 2013). Much like Allegiant, Delta seeks to earn revenue from "new product sales," which will enhance its flying experience for passengers. Although Delta's fleet is among the industry's oldest (averaging 15 years including its affiliates' aircraft in 2012), it pays much attention to aircraft maintenance (Bachman, 2013). Furthermore, it is taking preventive maintenance measures by purchasing (spare) aircraft to break up for its parts rather than to fly (Broderick, 2014). Delta's strategy is to minimize maintenance, materials, and repair costs, while ensuring a mature and reliable fleet.

The contrast between these four airlines challenges the claim that airlines try equally hard to improve efficiency due to the high cost of fuel. There is a clear distinction between airlines that invest in fuel efficiency to minimize operating costs and those that seek to minimize capital investments. While efficient carriers like Alaska and Spirit invest in fleet efficiency and operational improvements, the least efficient carriers, Allegiant, and increasingly Delta, are able to reap high profits by operating older, cheaper aircraft. There is a trade-off between financial and environmental costs, with some airlines choosing the latter.

16 U.S. Department of Transportation, BTS Form 41 Financial Data (2014).

4. CONCLUSIONS

This study updated the 2010 U.S. domestic airline fuel efficiency ranking with 2011 and 2012 data, and provided some insight as to how the fuel efficiency of individual airlines and the industry as a whole have changed over time. Alaska and Spirit have extended their lead as the two most efficient U.S. domestic airlines through advanced technology and efficient operational practices, while Allegiant and American continue to be the least fuel-efficient U.S. carriers. Overall, the fuel efficiency of U.S. domestic aviation improved by slightly over 2% from 2010 to 2012, with the major mergers that occurred during that period — Southwest-AirTran and United-Continental — having differing short-term effects on efficiency.

Looking forward, the lack of transparent, comprehensive data on fuel use and aircraft operations continues to be an obstacle to understanding airline efficiency. For some airlines, taking deliberate steps to improve their fleet or operations led to improvements in relative efficiencies. For others, the underlying reasons for their in-use efficiency (or lack thereof) cannot be completely explained by the data currently available. It is evident that some airlines are able to reap profits despite, or because of, their fuel-intensive business models. These findings should be of interest to policymakers working to address the environmental footprint of the aviation sector and travelers wishing to direct their business to less carbon-intensive airlines.

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APPENDIX A: FRONTIER MODEL APPROACH

This document, like the original 2010 baseline report, applies a methodology developed in collaboration with NEXTOR researchers at the University of California, Berkeley, to evaluate and compare the fuel efficiency of U.S. airlines on domestic routes. Quarterly reported traffic and fuel data provided by Data Base Products, a reseller of Form 41 U.S. air carrier data from the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS), is used to develop a statistical model normalizing each airline's fuel consumption by the transport service it provides.[17] The frontier model approach uses the best-performing airline(s) to benchmark the fuel efficiency of less-efficient airlines based upon both the revenue passenger miles (measure of mobility) and departures (measure of access) they provide (Kumbhakar & Knox Lovell, 2000). The model form is shown below in Equation A1, relating the input (fuel) of an airline *i* at time *t* to its output (RPM, departure):

$$fuel_{it} = f\,(RPM_{it},\, dep_{it}) + \eta_{it} \qquad \textbf{[Eq. A1]}$$

where η_{it} represents the airline's true inefficiency. Assuming that a log-linear function best describes the dataset, Equation A1 is transformed into the following functional form:

$$ln(fuel)_{it} = \beta_0 + \beta_1 ln(RPM)_{it} + \beta_2 ln(dep)_{it} + \xi_{it} \qquad \textbf{[Eq. A2]}$$

where β_0, β_1, and β_2 are the coefficients estimated from a single year's quarterly dataset of fuel consumption, RPMs, and departures. An ordinary least-squares regression is applied to estimate the two slopes β_1 and β_2 with an initial intercept β_0', based on which the residual ξ_{it} is calculated for each observation. For a population of airlines, one airline will provide the most transport service per unit fuel. This is represented mathematically by shifting β_0' downward until it becomes β_0 such that the most efficient airline-quarter has a residual of zero, thereby lying directly on an efficiency frontier. Figure A1 illustrates the concept of a frontier in two-dimensional form. The efficiency frontier (dotted line) represents the minimum fuel burned for a given level of transport service in Figure A1. Above the frontier line are four hypothetical airlines of varying sizes with each airline's deviation from the frontier line corresponding to its relative inefficiency. Thus, Airline 1 lying on the frontier is the most efficient, followed by Airline 2, then Airline 3, with Airline 4 being the least efficient.

17 U.S. Department of Transportation, BTS Form 41 Financial Data (2014).

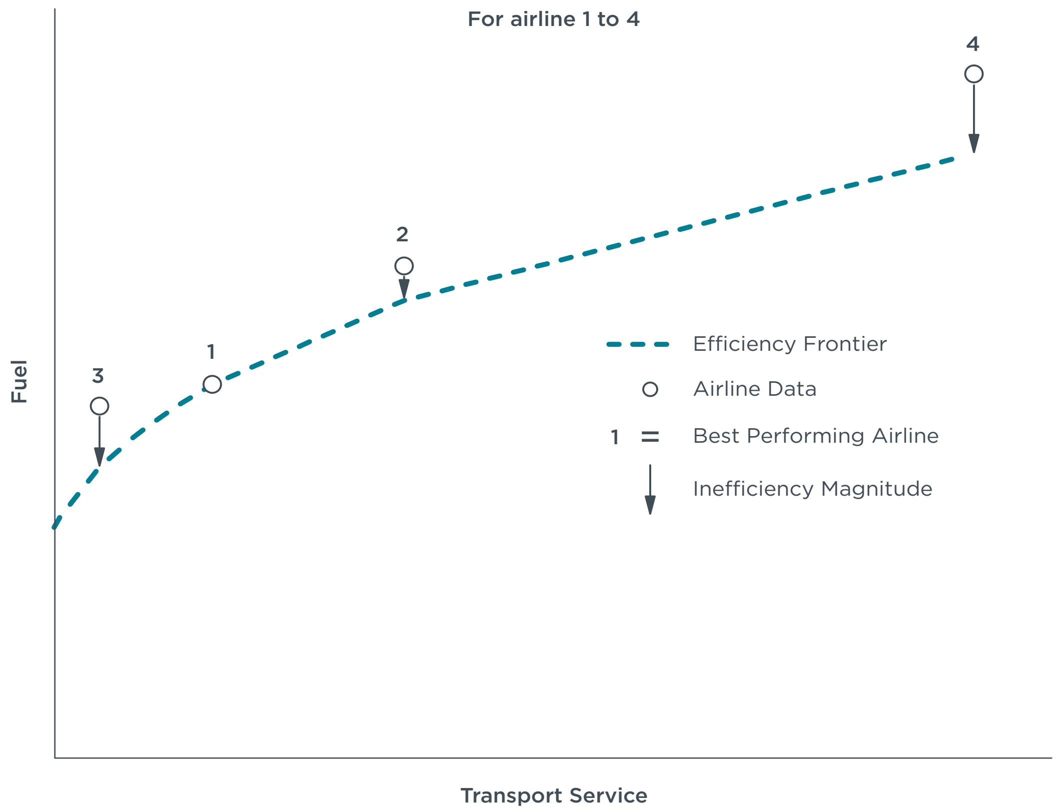

Figure A1. Frontier ranking approach

From Equation A2, $\exp(\xi_{it})$ measures inefficiency and is equal to $\frac{1}{\exp(\beta_0)} \cdot \frac{fuel_{it}}{RPM_{it}^{\beta_1} \cdot dep_{it}^{\beta_2}}$, where $\frac{1}{\exp(\beta_0)}$ is a constant across observations.[18] Because the airline industry is ever changing due to consolidation of carriers, streamlining of affiliations, routing maps, operations, and other reasons, unique frontier regression models are calculated for each year 2011 and 2012, creating a slightly different weighting factor for RPMs and departures for each year in the survey.

The model incorporates regional carriers through the apportionment of their RPMs, departures, and fuel to corresponding mainline carriers. The 2011 and 2012 airline fuel efficiency ranking assign the regional affiliates via a refined method using the BTS Airline Origin and Destination Survey (DB1B). DB1B data was also used to calculate circuity, which measures the degree to which airlines deviate from direct flight paths due to one or more layovers that require extra travel. It measures the excess amount of distance traveled along great circle routes to go from origin airport O to a final airport D compared to the great circle distance (GCD) separating them. Circuity is calculated as the ratio of BTS reported passenger miles traveled to the passenger miles that would have been traveled if all flights followed a hypothetical line directly connecting the two airports (Equation A3).

$$Circuity = \frac{\text{total GCD pax-mi flown}}{\text{total GCD pax-mi if all flights flown nonstop}} \qquad \textbf{[Eq. A3]}$$

18 Zou et al. (2012) present the metric in full technical detail, including a comparison with alternative metrics.

Thus, circuity is equal to 1 when a flight is direct and greater than 1 if a flight is longer than necessary. In the frontier approach, circuity is accounted for by adjusting an airline's RPMs with its average circuity (Equation A4):

$$RPM_{adj} = \frac{RPM}{Circuity} \qquad \textbf{[Eq. A4]}$$

The adjusted RPM values represent "productive" passenger miles flown. Essentially, airlines with higher circuity are penalized by having a lower RPM output for the same fuel burned. As a result, the methodology properly credits airlines that operate more efficiently by flying their passengers directly to their intended destination.[19]

Considerable effort was expended to work with Data Base Products to identify and rectify incorrect data due to misreporting to BTS or some other unknown reason. [20] When necessary, a multi-step approach is taken to identify and exclude outliers from the analysis. First, a preliminary frontier model is generated using all quarters for the mainline airlines, and residuals calculated for each airline-quarter. Quarters with residuals greater than 0.2 are identified as candidate outliers. In the second step, the fuel per RPM ratio for candidate outliers is compared to the carrier's remaining quarters, with quarters deviating by more than 20% confirmed as outliers and excluded from further analysis. Outliers are more common for smaller rather than larger airlines. For example, in this survey, AirTran (Q3 2011), Frontier (Q1 2011), and Virgin (Q1 2012) were outlier quarters that were removed from the frontier model calculation. Furthermore, several regional affiliates did not report their fuel values and were thus estimated using a fuel regression model. In 2011, quarterly data for 17 other affiliates were used to determine a fuel regression model, Equation A5 (standard errors in parentheses), to estimate fuel for Piedmont, Commutair, and Chautauqua. The fourth quarter of American Eagle and Executive Airlines were found to be outliers as suggested from preliminary results, and therefore, excluded from the model.

$$\underset{}{ln(fuel)} = \underset{(0.419)}{-0.696} + \underset{(0.034)}{0.717}\, ln(RPM) + \underset{(0.040)}{0.282}\, ln(dep) \qquad \textbf{[Eq. A5]}$$

Number of observations: 66 $\qquad R^2 = 0.974$

Similarly in 2012, Piedmont, Commutair, and Chautauqua (only Q1 and Q2) did not report their fuel burn values. Quarterly data of 14 other affiliates are used to estimate the fuel burn for those three carriers via a fuel regression model, Equation A6. Shuttle America (Q1) and Executive Airlines (all quarters) were found to be outliers and excluded from the model.

$$ln(fuel) = \underset{(0.771)}{-2.085} + \underset{(0.061)}{0.793}\, ln(RPM) + \underset{(0.061)}{0.266}\, ln(dep) \qquad \textbf{[Eq. A6]}$$

Number of observations: 54 $\qquad R^2 = 0.958$

Likewise, ExpressJet's fuel consumption data in 2012, following its late 2011 merger with Atlantic Southeast Airlines, appeared erroneous. A statistical model of 2011 affiliate fuel consumption (Equation A5) was used to estimate the average efficiency of ExpressJet.

19 Since the DB1B sample data does not indicate when passengers transit airports without changing planes, and does not track actual flight paths between airports, circuity somewhat underestimates the level of indirect flight taking place.

20 Data Base Products, personal communication, March 2014.

Assuming that its efficiency in 2012 was close to that of 2011, its fuel was revised downward by 26%.

After accounting for outliers in the dataset, the total fuel consumption, RPMs, and departures of mainline carriers and their affiliates for 2011 and 2012 were characterized by Equations A7 and A8, respectively.

$$\underset{}{ln(fuel)_{it}} = \underset{(0.754)}{-1.913} + \underset{(0.056)}{0.800}\, ln(RPM)_{it} + \underset{(0.046)}{0.219}\, ln(dep)_{it} + \xi_{it} \qquad \textbf{[Eq. A7]}$$

Number of observations: 58 $R^2 = 0.997$

$$\underset{}{ln(fuel)_{it}} = \underset{(0.754)}{-1.678} + \underset{(0.056)}{0.781}\, ln(RPM)_{it} + \underset{(0.046)}{0.234}\, ln(dep)_{it} + \xi_{it} \qquad \textbf{[Eq. A8]}$$

Number of observations: 51 $R^2 = 0.997$

An airline's inefficiency is calculated by taking the average of its airline-quarter inefficiency measures, $exp(\xi_{it})$, in a year. A unitless fuel efficiency score (FES) for each airline is calculated by normalizing its inefficiency value by the simple average inefficiency across all airlines, with higher FES indicating relatively higher fuel efficiency.

APPENDIX B: 2011 FUEL EFFICIENCY SCORES

Figure B1 summarizes each airline's fuel efficiency score (FES) for U.S. domestic operations in 2011. The rightmost values in grey show excess fuel burn relative to the most efficient airline in this survey (Alaska).

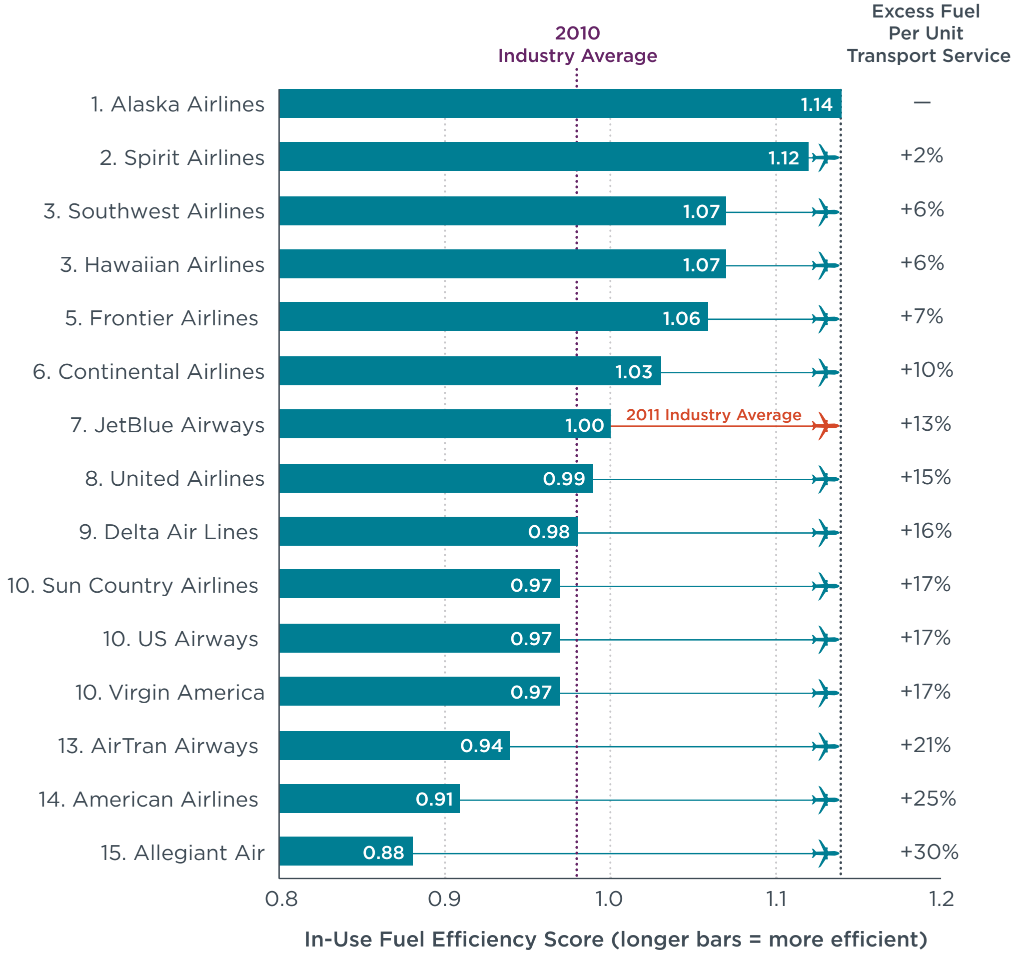

Figure B1. Fuel efficiency scores by airline for U.S. domestic operations in 2011 (higher score means greater efficiency)

Alaska Airlines was the most efficient U.S. domestic carrier in 2011 with an FES of 1.14. Spirit Airlines came in second with a score of 1.12, consuming 2% more fuel per unit transport service. Southwest and Hawaiian tied for third, separated from Alaska by a full 6%. In fifth was Frontier, which improved from sixth place in 2010 due to operational improvements (e.g., a 6% increase in load factor) and more efficient technology. Frontier added nine Airbus A320s to its fleet in 2011, while also phasing out its older, less efficient A318s. Figure B2 shows Frontier's increasing use of its A320 aircraft, which both seat more passengers and have higher seat densities than its other aircraft. The average passenger load factor on Frontier's A320 aircraft was 91% in 2011, allowing it to achieve about 30% more RPM output per fuel burned than its more common A319s.

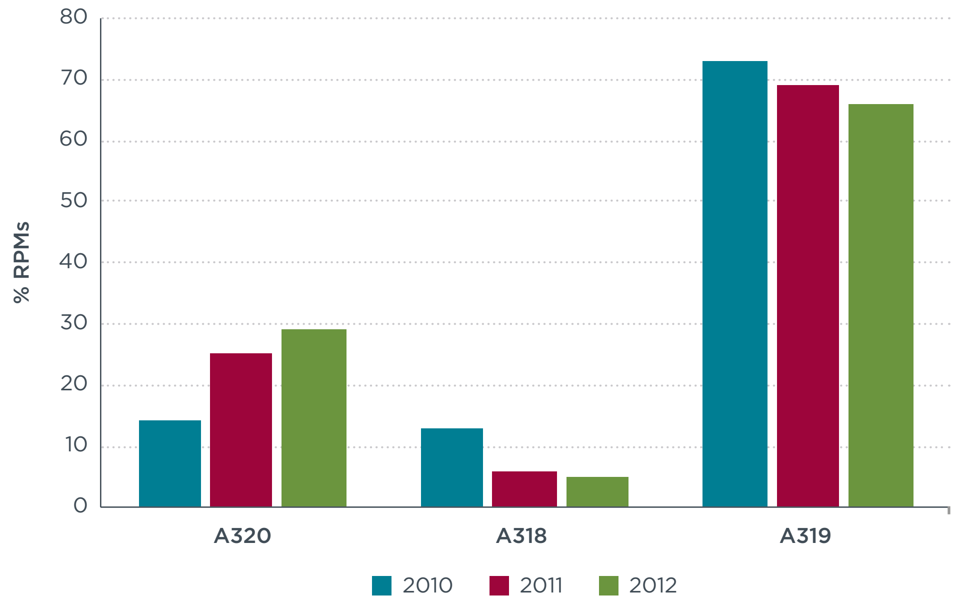

Figure B2. Revenue passenger miles by aircraft type for Frontier Airlines, 2010–2012

Continental Airlines dropped from fourth most efficient carrier in 2010 to sixth in 2011. JetBlue Airways was the industry average carrier (FES = 1.00) in 2011, followed by United and Delta, while Sun Country, US Airways, and Virgin America were all tied for tenth in terms of in-use efficiency. AirTran and American were ranked thirteenth and fourteenth, consuming over 20% more fuel than Alaska to provide a comparable level of transport service. Allegiant, with an FES of 0.88, remained the least fuel-efficient U.S. domestic carrier in 2011. The gap in efficiency between Allegiant and Alaska increased from 26% in 2010 to 30% in 2011. The dotted purple line in Figure B1 representing the industry average efficiency in 2010 indicates a 1.2% improvement over that one-year period.

APPENDIX C: SUPPLEMENTAL DATA

Table C1. Mainline fuel gallons (millions)

Carrier	2010	2011	2012
AirTran	367	336	–
Alaska	298	319	341
Allegiant	106	108	119
American	1,511	1,450	1,429
Continental	652	675	–
Delta	1,707	1,615	1,570
Frontier	160	173	148
Hawaiian	123	123	137
JetBlue	418	448	475
Southwest	1,439	1,509	1,814
Spirit	78	101	123
Sun Country	23	27	30
United	991	916	1,540
US Airways	824	820	823
Virgin America	101	124	143

Source: Data Base Products (2014)

Table C2. Mainline revenue passenger miles (billions)

Carrier	2010	2011	2012
AirTran	18.7	19.0	–
Alaska	18.7	20.7	22.5
Allegiant	5.4	5.6	6.5
American	77.3	76.3	75.2
Continental	41.4	42.3	–
Delta	92.7	92.0	92.9
Frontier	8.6	9.8	9.4
Hawaiian	7.7	7.8	8.6
JetBlue	24.2	26.2	28.3
Southwest	78.1	83.9	101.4
Spirit	5.5	6.7	8.3
Sun Country	1.4	1.6	1.7
United	57.3	53.9	93.9
US Airways	43.9	45.1	46.7
Virgin America	6.2	7.8	9.6

Source: Data Base Products (2014)

Table C3. Mainline departures

Carrier	2010	2011	2012
AirTran	246,008	246,224	–
Alaska	142,909	148,296	151,389
Allegiant	44,308	45,425	49,805
American	546,025	538,098	529,294
Continental	243,155	248,163	–
Delta	729,873	730,100	732,265
Frontier	80,213	85,608	79,266
Hawaiian	68,524	67,446	74,611
JetBlue	197,995	212,996	227,320
Southwest	1,115,311	1,145,776	1,350,388
Spirit	45,258	54,992	68,176
Sun Country	10,968	13,159	14,656
United	350,190	316,749	542,130
US Airways	405,593	407,553	405,256
Virgin America	35,737	43,293	54,456

Source: Data Base Products (2014)

Table C4. Mainline average taxi time (minutes per flight)

Carrier	2010	2011	2012
AirTran	22.6	21.6	–
Alaska	19.5	19.4	19.4
Allegiant	19.7	20.4	20.4
American	23.6	23.1	23.8
Continental	24.6	25.6	–
Delta	29.2	28.3	27.1
Frontier	21.4	21.2	20.7
Hawaiian	16.3	16.1	16.3
JetBlue	24.8	24.9	23.4
Southwest	15.4	15.4	16.5
Spirit	22.0	22.8	22.7
Sun Country	18.5	18.5	18.8
United	22.7	23.1	24.7
US Airways	25.0	25.6	24.7
Virgin America	22.0	22.0	25.8

Source: Data Base Products (2014)

Table C5. Affiliate fuel gallons (millions)

Carrier	2010	2011	2012
Air Wisconsin	77.158	77.568	77.065
American Eagle	263.622	292.486	298.752
Atlantic Southeast	169.386	176.879	(Merged with ExpressJet)
Chautauqua	N/A*	N/A*	34.211*
Colgan	24.626	34.100	13.936
Comair	100.380	87.257	45.098
Commutair	N/A*	N/A*	N/A*
Compass	55.259	66.278	72.839
Executive	13.187	12.666	6.708
ExpressJet	208.430	281.213	467.952[1]
Freedom	N/A*	(Ceased operations)	(Ceased operations)
GoJet	30.369	42.360	55.848
Horizon	59.112	49.668	43.674
Mesa	91.273	92.844	93.610
Mesaba	94.125	87.930	(Ceased operations)
Piedmont	N/A*	N/A*	N/A*
Pinnacle	148.244	144.795	208.442
PSA	60.383	60.541	62.596
Republic	152.893	144.821	129.123
Shuttle America	57.923	92.481	122.083
SkyWest	352.900	358.810	349.924
Trans States[2]	N/A*	N/A*	N/A*

*Did not report fuel consumption data to BTS; Chautauqua began to report in 2012 Q3
[1] Estimated from a statistical model of 2011 affiliate fuel consumption
[2] Trans States (AX) was not found in the DB1B 10% sample
Source: Data Base Products (2014)

Table C6. Affiliate revenue passenger miles (billions)

Carrier	2010	2011	2012
Air Wisconsin	1.963	1.941	2.092
American Eagle	7.802	8.820	9.216
Atlantic Southeast	5.732	6.047	(ExpressJet)
Chautauqua	2.093	1.874	1.552
Colgan	0.693	1.079	0.488
Comair	3.126	2.531	1.318
Commutair	0.151	0.171	0.241
Compass	2.337	2.666	2.960
Executive	0.264	0.296	0.071
ExpressJet	8.600	8.531	14.853
Freedom	0.315	(Ceased operations)	(Ceased operations)
GoJet	1.627	1.704	2.145
Horizon	2.451	2.104	2.039
Mesa	4.074	3.873	3.598
Mesaba	3.560	3.211	(Ceased operations)
Piedmont	0.518	0.533	0.547
Pinnacle	4.668	4.450	6.972
PSA	1.696	1.750	1.893
Republic	6.089	5.665	4.890
Shuttle America	3.212	3.088	3.628
SkyWest	13.261	13.617	14.192
Trans States	0.855	N/A	N/A

Source: Data Base Products (2014)

Table C7. Affiliate departures

Carrier	2010	2011	2012
Air Wisconsin	165,473	167,929	168,581
American Eagle	454,538	459,471	486,634
Atlantic Southeast	320,502	326,508	(Merged with ExpressJet)
Chautauqua	164,546	153,842	133,082
Colgan	104,386	121,557	53,602
Comair	153,332	130,245	60,480
Commutair	35,373	38,370	45,834
Compass	57,480	61,370	67,197
Executive	45,121	43,928	10,864
ExpressJet	399,082	413,398	757,250
Freedom	21,945	(Ceased operations)	(Ceased operations)
GoJet	51,506	46,454	65,294
Horizon	131,648	117,720	117,615
Mesa	175,322	154,926	135,055
Mesaba	158,094	134,750	(Ceased operations)
Piedmont	115,999	116,145	118,021
Pinnacle	272,705	261,725	335,270
PSA	121,002	116,258	120,972
Republic	173,709	168,484	155,771
Shuttle America	99,531	105,887	116,920
SkyWest	625,685	616,230	636,616
Trans States	58,813	N/A	N/A

Source: Data Base Products (2014)

Table C8. Mainline-affiliate revenue passenger miles distribution, 2011 and 2012

Mainline Carrier	Affiliated Carriers	Apportioned RPMs (millions)		% RPMs Carried by Affiliates	
		2011	2012	2011	2012
AirTran	AirTran	18,991			
	SkyWest	94			
		Total 19,085		0.5%	N/A
Alaska	Alaska	20,652	22,500		
	American Eagle	72	51		
	Atlantic Southeast	1			
	Chautauqua	1	1		
	Compass	2	1		
	Executive	<0.5			
	ExpressJet		<0.5		
	Horizon	2,023	1,988		
	Mesaba	1			
	Pinnacle	1	1		
	SkyWest	339	511		
		Total 23,094	Total 25,053	11%	10%
American	American	76,275	75,204		
	American Eagle	8,731	9,160		
	Chautauqua	447	383		
	Executive	296			
	ExpressJet		<0.5		
	Horizon	46	23		
	SkyWest	<0.5	53		
		Total 85,795	Total 84,823	11%	11%

continued

Table C8. Mainline-affiliate revenue passenger miles distribution, 2011 and 2012

Mainline Carrier	Affiliated Carriers	Apportioned RPMs (millions)		% RPMs Carried by Affiliates	
		2011	2012	2011	2012
Continental	Continental	42,347			
	Air Wisconsin	<0.5			
	Atlantic Southeast	3			
	Chautauqua	326			
	Colgan Air	776			
	Commutair	171			
	ExpressJet	5,148			
	GoJet	5			
	Mesa	115			
	Piedmont	<0.5			
	Republic	<0.5			
	Shuttle America	122			
	SkyWest	600			
		Total 49,612		**15%**	**N/A**
Delta	Delta	91,977	92,892		
	American Eagle	14	3		
	Atlantic Southeast	5,666			
	Chautauqua	693	530		
	Comair	2,530	1,318		
	Commutair	<0.5			
	Compass	2,664	2,959		
	ExpressJet	<0.5	5,584		
	GoJet		616		
	Horizon	34	27		
	Mesaba	3,168			
	Pinnacle	4,449	6,971		
	Shuttle America	1,063	1,403		
	SkyWest	4,913	4,651		
		Total 117,170	**Total 116,953**	**22%**	**21%**

continued

Table C8. Mainline-affiliate revenue passenger miles distribution, 2011 and 2012

Mainline Carrier	Affiliated Carriers	Apportioned RPMs (millions)		% RPMs Carried by Affiliates	
		2011	2012	2011	2012
Frontier	**Frontier**	9,780	9,393		
	Chautauqua	123	11		
	ExpressJet	<0.5			
	Republic	2,302	1,553		
		Total 12,205	**Total 10,958**	**20%**	**14%**
Hawaiian	**Hawaiian**	7,771	8,591		
	SkyWest	<0.5	<0.5		
		Total 7,771	**Total 8,591**	**~0**	**~0**
United	**United**	53,855	93,903		
	Air Wisconsin	9	9		
	American Eagle	<0.5			
	Atlantic Southeast	378			
	Chautauqua	3	349		
	Colgan	247	476		
	Commutair	<0.5	241		
	ExpressJet	3,322	9,067		
	GoJet	1,682	1,470		
	Mesa	1,054	1,129		
	Mesaba	<0.5			
	Piedmont	24	25		
	PSA	40	40		
	Republic	3	85		
	Shuttle America	1,876	2,146		
	SkyWest	7,551	8,152		
		Total 70,043	**Total 117,092**	**23%**	**20%**

continued

Table C8. Mainline-affiliate revenue passenger miles distribution, 2011 and 2012

Mainline Carrier	Affiliated Carriers	Apportioned RPMs (millions)		% RPMs Carried by Affiliates	
		2011	2012	2011	2012
US Airways	**US Airways**	45,084	46,658		
	Air Wisconsin	1,932	2,083		
	Chautauqua	281	278		
	Colgan	56	12		
	Commutair		<0.5		
	ExpressJet	61			
	GoJet	17	59		
	Mesa	2,666	2,433		
	Mesaba	42			
	Piedmont	510	523		
	PSA	1,710	1,853		
	Republic	3,361	3,252		
	Shuttle America	27	79		
	SkyWest	112	741		
		Total 55,857	**Total 58,164**	**19%**	**20%**

Source: Data Base Products (2014)

Table C9. Affiliate contribution to mainline RPMs (%)

Carrier	2010	2011	2012
AirTran	0	1	-
Alaska	12	11	10
American	10	11	11
Continental	17	15	-
Delta	21	22	21
Frontier	21	19	14
United	22	23	20
US Airways	20	19	20

Source: Data Base Products (2014)

Table C10. Mainline-affiliate average circuity

Carrier	2010	2011	2012
AirTran	1.05	1.04	-
Alaska	1.04	1.04	1.04
Allegiant	1.00	1.00	1.00
American	1.04	1.05	1.05
Continental	1.05	1.05	-
Delta	1.06	1.07	1.08
Frontier	1.04	1.03	1.03
Hawaiian	1.01	1.01	1.01
JetBlue	1.01	1.01	1.01
Southwest	1.03	1.04	1.04
Spirit	1.01	1.01	1.01
Sun Country	1.00	1.00	1.00
United	1.04	1.05	1.05
US Airways	1.07	1.08	1.08
Virgin America	1.01	1.01	1.01

Source: Data Base Products (2014)

Table C11. Mainline-affiliate average passenger load factor (%)

Carrier	2010	2011	2012
AirTran	81	80	-
Alaska	82	84	86
Allegiant	90	91	89
American	82	82	83
Continental	83	82	-
Delta	83	83	84
Frontier	82	87	88
Hawaiian	86	86	87
JetBlue	82	83	84
Southwest	79	81	80
Spirit	83	86	86
Sun Country	70	71	71
United	83	84	84
US Airways	82	83	85
Virgin America	82	82	79

Source: Data Base Products (2014)

Table C12. Mainline-affiliate average stage length (miles)

Carrier	2010	2011	2012
AirTran	748	753	-
Alaska	715	737	753
Allegiant	914	901	913
American	765	767	775
Continental	711	722	-
Delta	624	620	646
Frontier	732	718	752
Hawaiian	557	557	550
JetBlue	1,075	1,065	1,065
Southwest	648	664	687
Spirit	953	912	894
Sun Country	1,159	1,119	1,106
United	713	721	720
US Airways	545	554	559
Virgin America	1,546	1,554	1,564

Source: Data Base Products (2014)

Table C13. Mainline-affiliate average aircraft age (years)

Carrier	2010	2011	2012
AirTran	6.6	7.5	-
Alaska	6.1	6.5	7.0
Allegiant	20.8	21.7	22.5
American	14.7	14.2	14.3
Continental	8.1	8.7	-
Delta	13.2	14.1	15.0
Frontier	5.2	5.7	6.5
Hawaiian	12.7	11.3	10.6
JetBlue	5.3	6.0	6.6
Southwest	10.1	10.2	10.2
Spirit	3.7	4.1	4.4
Sun Country	8.9	9.9	11.0
United	12.6	13.8	12.1
US Airways	10.3	10.8	10.9
Virgin America	2.9	2.9	3.4

Source: Data Base Products (2014); Ascend Online Fleets (2014)

Table C14. Mainline-affiliate average aircraft gauge (seats per flight)

Carrier	2010	2011	2012
AirTran	126	126	-
Alaska	142	144	144
Allegiant	149	151	161
American	153	151	151
Continental	148	154	-
Delta	147	150	152
Frontier	126	131	137
Hawaiian	250	257	260
JetBlue	142	142	142
Southwest	136	137	137
Spirit	156	158	161
Sun Country	153	152	149
United	152	150	149
US Airways	138	138	140
Virgin America	140	141	142

Source: Data Base Products (2014)

Table C15. Mainline net operating profit margin (%)[1]

Carrier	2010	2011	2012	2009-2011	2010-2012
AirTran	4.9	-0.6	-	3.7	-
Alaska	14.4	11.5	12.6	11.3	12.7
Allegiant	13.7	8.6	12.3	13.5	11.5
American	1.2	-6.2	-2.4	-4.3	-2.5
Continental	-9.5	-7.3	-	-10.1	-
Delta	11.1	11.5	7.7	9.4	10.0
Frontier	-2.0	-8.8	1.3	-2.7	-3.5
Hawaiian	7.5	-1.1	4.2	5.8	3.4
JetBlue	6.2	3.2	4.5	5.5	4.6
Southwest	8.2	4.8	3.7	5.3	5.3
Spirit	8.5	14.8	13.2	12.6	12.6
Sun Country	5.0	-2.3	2.6	1.7	1.6
United	3.2	0.6	-4.0	1.4	-0.8
US Airways	5.4	2.6	5.3	3.2	4.4
Virgin America	-0.1	-1.4	-1.6	-3.1	-1.2

[1] Profit/loss (+/-)
Source: Data Base Products (2014)

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