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U.S. DOMESTIC AIRLINE FUEL EFFICIENCY RANKING, 2015–2016

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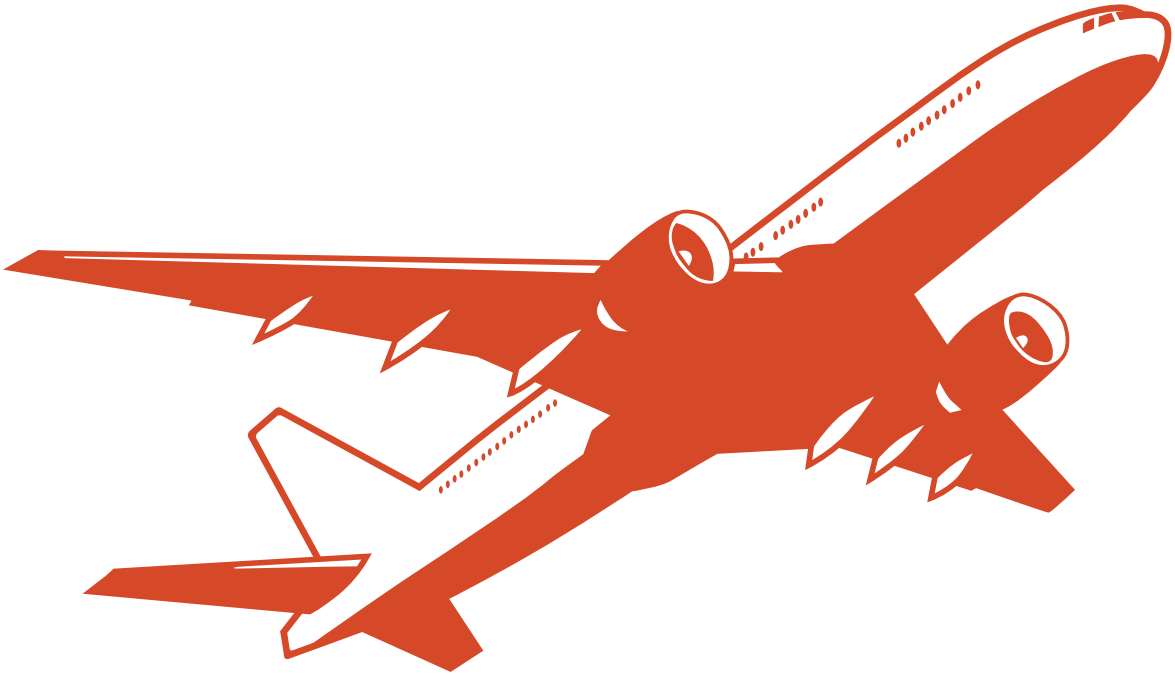

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1. INTRODUCTION

Aviation is an important part of the global economy, and demand for aviation services is growing. In a recent report, the Federal Aviation Administration projects that aviation activity will increase 2% to 3% annually through 2037 (FAA, 2017a). At present, aircraft account for about 2.5% of global carbon dioxide (CO_2) emissions. U.S. aircraft alone account for 30% of the CO_2 emissions from global aviation and 12% of U.S. transportation emissions (U.S. EPA, 2016). Recognizing the importance of aviation emissions, the U.S. government set an aspirational goal of capping CO_2 emissions from U.S. commercial carriers at 2005 levels from 2020 (U.S., 2015).

Increasingly, individuals, companies, and organizations are becoming concerned with the contribution of air travel to their carbon footprint. But little public information is available to help consumers reduce their carbon footprint by choosing more fuel-efficient airlines.

In 2013 the International Council on Clean Transportation (ICCT) began to publish annual fuel efficiency rankings of major U.S. domestic airlines. The series eventually covered the years 2010 through 2014 (Zeinali, Rutherford, Kwan, & Kharina, 2013, Kwan, Rutherford, & Zeinali, 2014a, Kwan & Rutherford, 2014b, Li, Kwan, & Rutherford, 2015). U.S. air carriers have changed in important ways since 2014. Industry consolidation continues apace. In April 2015, American Airlines and US Airways completed their merger (Karp 2015), and the new entity is the largest domestic air carrier by revenue passenger miles (RPMs). In April 2016, Alaska Airlines announced it would purchase Virgin America for $2.6 billion (Kottasova and Wattles, 2016). Since 2014, U.S. domestic air carriers become historically profitable due to the 2014 collapse of oil prices and the expansion of ancillary fees for such perks as seating with extra legroom, entertainment, Wi-Fi, food and beverages, and checked baggage.

This report carries forward that annual U.S. domestic airline fuel efficiency ranking series through 2015 and 2016. Key findings include:

1. Alaska, Frontier, and Spirit remained the most fuel-efficient air carriers on U.S. operations in 2015 and 2016. Virgin America was the least efficient carrier both years.
2. The fuel-efficiency gap between the most-efficient and least-efficient airlines increased slightly from 25% in 2014 to 26% in 2016.
3. Rapid growth in RPMs outstripped fuel efficiency improvements, causing overall fuel use and CO_2 emissions to jump. From 2014 to 2016, domestic RPMs increased 10%, fleetwide efficiency improved by 3%, and fuel use increased by 7%.
4. Since the fuel price peak in 2012, the average profit margin for domestic carriers has increased nearly sixfold, from 3% in 2012 to 17% in 2016, due to lower fuel prices and higher ancillary fees. Of the estimated $17 billion in fuel savings, 20% were devoted to lower fares for travelers.

This report is structured as follows. First, we provide a brief overview of the ranking methodology, which has been well described in previous studies. Next, we outline high-level findings from the work, including the relative rankings of airlines, the drivers of their efficiency, and industrywide trends in demand, fuel use, and profitability. In closing, we discuss the implications of this research and identify areas of future work.

2. METHODOLOGY

This update, like the previous rankings, evaluates the fuel efficiency of U.S. airlines' domestic operations using a deterministic frontier model. The frontier approach benchmarks carriers using a fuel per transport service metric based on data reported by airlines to the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS) (Airline Data, Inc. 2017).[1] That approach allows for the comparison of airlines, irrespective of business model, in a fair and transparent manner.

Transport service accounts for both mobility, measured by RPMs, and access, measured by the number of airports served or flight frequency (departures). This ensures that the model equitably compares airlines operating under various business models (e.g., point-to-point vs. hub-and-spoke, predominately short haul vs. longer coast-to-coast flights, etc.). The fuel consumed per unit of transport service is compared to that of the most efficient airline by quarter in order to generate a Fuel Efficiency Score (FES).

Quarterly RPMs, departures, and fuel burn data for 2015 and 2016 are provided by Airline Data Inc. (formerly Data Base Products), a reseller of BTS U.S. air carrier data. These data are used to develop the statistical frontier model, which relates the input, fuel, of an airline *i* at time *t* to its output, revenue passenger miles (RPM) and departures (dep):

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

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

Assuming a log-linear function best describes the relationship between the input and output variables, Equation 1 is transformed into the following functional form:

$$ln(fuel)_{it} = \beta_0 + \beta_1 ln(RPM)_{it} + \beta_2 ln(dep)_{it} + \xi_{it} \qquad \text{[Eq. 2]}$$

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. Some air carriers operate a significant portion of their flights through the use of regional affiliates. To account for this, RPMs, departures, and fuel use of regional affiliates are apportioned to their respective mainline carriers using BTS T100 data.[2] The function also takes into account circuity, measured as the degree to which air carriers' flight paths deviate from direct origin-destination distance as a result of layovers (Zeinali, Rutherford, Kwan, & Kharina, 2013).

In some cases, air carriers misreported their fuel burn, RPMs, or departures to BTS. When possible, we corrected the data using revised data supplied by the air carrier itself. When corrected data were unavailable, erroneous data was backfilled using the relationship between fuel burn, RPMs, and departures for similar data points. For example, if an airline's 2016 Quarter 1 fuel burn value for a specific aircraft was determined to be an outlier, the fuel burn was backfilled based on a log-linear regression for that specific air carrier and aircraft type for the remaining quarters of 2015 and 2016.

1 For a more in-depth discussion on the frontier model methodology, see Zou et al. (2012).

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

The resulting frontier model representing 2015 airline fuel consumption, with standard error in parentheses, is:

$$\ln(fuel) = 3.812 + 0.763 \times \ln(RPM) + 0.248 \times \ln(dep) \quad \text{[Eq. 3]}$$
$$\text{(0.594)} \quad \text{(0.089)} \quad \text{(0.074)}$$

Number of observations: 48 R^2*: 0.997*

Similarly, the resulting frontier model representing 2016 airline fuel consumption, with standard error in parentheses, is:

$$\ln(fuel) = 4.613 + 0.634 \times \ln(RPM) + 0.360 \times \ln(dep) \quad \text{[Eq. 4]}$$
$$\text{(0.571)} \quad \text{(0.083)} \quad \text{(0.068)}$$

Number of observations: 48 R^2*: 0.997*

Each airline's FES is calculated by normalizing its inefficiency value by the simple average across all airlines. Thus, a higher FES (>1) indicates relatively higher fuel efficiency, while a lower FES (<1) indicates relatively lower fuel efficiency. See Zeinali, Rutherford, Kwan, & Kharina (2013) for further details.

3. FINDINGS

This section summarizes the relative fuel efficiency of airlines in 2016 (the main ranking, Section 3.1); individual airlines' performance over time (3.2); industrywide changes in demand, fuel efficiency, and fuel use (3.3); and trends in airline profitability, fares, and fuel costs (3.4). The 2015 results are provided in Appendix A.

3.1 HIGH LEVEL FINDINGS

FES for 2016 U.S. domestic air carriers are presented in Figure 1.

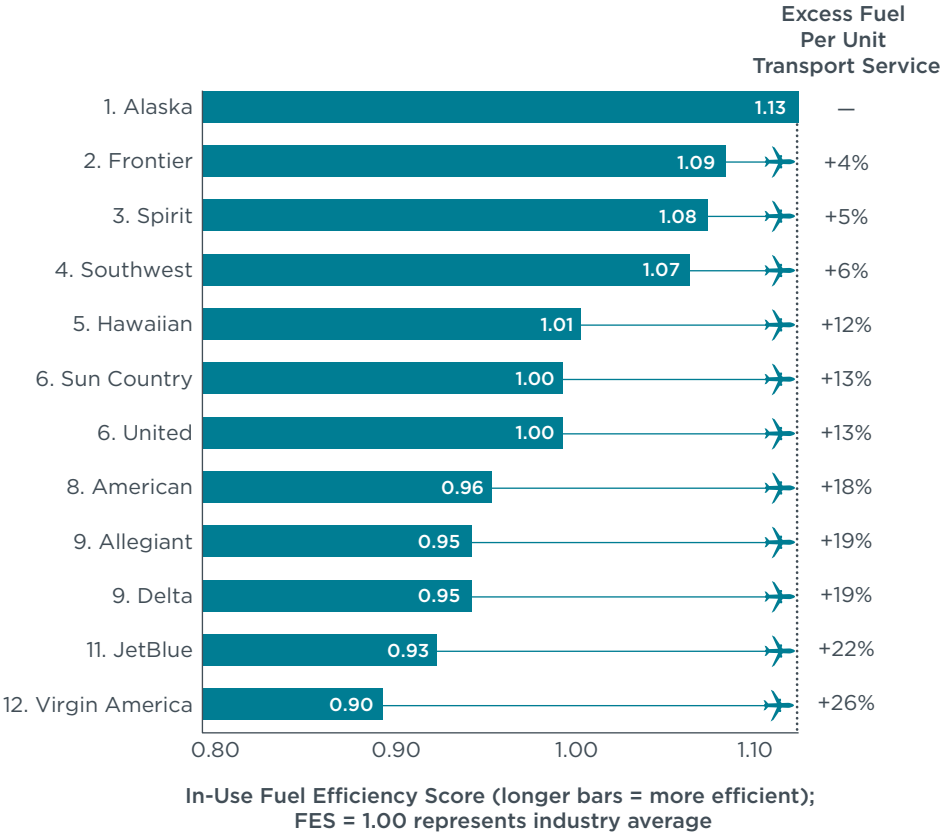


Figure 1. Fuel Efficiency Scores by airline for U.S. domestic operations, 2016.

As shown in Figure 1, Alaska was the most fuel-efficient carrier on U.S. domestic operations in 2016, a position it has held continuously since 2010. Although Spirit maintained its second place ranking in 2015, in 2016, Frontier overcame Spirit as the second most fuel-efficient airline, likely resulting from its increased use of high-gauge A321s with more seats. Southwest came in fourth place both years, a position it has maintained since 2013. In 2016, these three carriers burned between 4 and 6% more fuel than Alaska per unit transport service, noticeably better than the industry average (FES = 1.00).

Three carriers—Hawaiian, United, and Sun Country—had fuel efficiencies close to the industry average. In 2015, Hawaiian and United tied for fifth in terms of fuel efficiency at the industry average, with Sun Country close behind in sixth place. However, Hawaiian nosed ahead of United with an FES of 1.01 in 2016, while Sun Country moved up to tie with United for the industry average. This is a notable improvement for Sun Country since 2014, when it was fourth from the bottom in terms of efficiency. Sun Country's

improvements are linked to a substantial (7%) increase in the average number of passengers per flight, as described in the following section.

The remaining five U.S. carriers had fuel efficiencies noticeably worse than average in 2016. American in eighth place consumed 18% more fuel than Alaska on comparable flights. American Airlines notably improved its FES from prior years, possibly as a result of its merger with US Airways, a mid-tier carrier in terms of efficiency. Delta and Allegiant consumed 19% more fuel than Alaska on comparable flights and tied for ninth place in terms of fuel efficiency in 2016. Virgin America was the least-efficient airline in both 2015 and 2016, burning 26% more fuel compared to Alaska in 2016. The gap between the most-efficient and least-efficient airlines widened slightly in 2016 to 26%.

3.2 KEY AIRLINE FINDINGS

The airline fuel efficiency rankings for 2010–2016 are presented in Table 1 below. The table highlights the shift in rankings over time, as well as mergers and ties (asterisks). As a result of industry consolidation (the United-Continental, Southwest-AirTran, and American-US Airways mergers indicated by the arrows), the total number of airlines analyzed dropped from 15 in 2010 to 12 in 2016.

Table 1. Airline fuel efficiency rankings for U.S. domestic operations, 2010-2016.

Rank	2010	2011	2012	2013	2014	2015	2016	Rank
1	Alaska	Alaska	Alaska	Alaska*	Alaska	Alaska	Alaska	1
2	Spirit*	Spirit	Spirit	Spirit*	Spirit	Spirit	Frontier	2
3	Hawaiian*	Southwest*	Southwest*	Frontier*	Frontier	Frontier	Spirit	3
4	Continental	Hawaiian*	Hawaiian*	Southwest	Southwest	Southwest	Southwest	4
5	Southwest	Frontier	Frontier	Hawaiian	United	Hawaiian*	Hawaiian	5
6	Frontier	Continental	United	United	Hawaiian	United*	Sun Country*	6
7	JetBlue	JetBlue	JetBlue	JetBlue	US Airways	Sun Country	United*	7
8	United	United	Virgin America	Delta	Allegiant	Delta	American	8
9	Virgin America	Delta	Delta	Virgin America	JetBlue	Allegiant*	Allegiant*	9
10	Sun Country	Sun Country	US Airways	US Airways	Sun Country	American*	Delta*	10
11	Delta	US Airways	Sun Country	Sun Country	Delta	JetBlue*	JetBlue	11
12	US Airways	Virgin America	Allegiant	Allegiant	Virgin America	Virgin America	Virgin America	12
13	AirTran	AirTran	American	American	American	—	—	
14	American	American	—	—	—	—	—	
15	Allegiant	Allegiant	—	—	—	—	—	

** Denotes ties between airlines in a given year*

Alaska holds the distinction of being the most fuel-efficient U.S. domestic airline for seven years running. Although Spirit held second place from 2010 to 2015, in 2016 Frontier overtook Spirit as second most fuel-efficient airline. In 2015, Frontier began deploying Airbus A321s and by 2016, the A321 accounted for almost 20% of its RPMs. By increasing its use of the larger and more efficient A321s, Frontier increased its overall gauge by 12% and its average efficiency (RPMs/fuel) by 8% between 2015 and

2016. Southwest Airlines, which flies an all Boeing 737 fleet on point-to-point service throughout the U.S., has consistently ranked fourth since 2013.

Hawaiian and United have traditionally shown fuel efficiencies at or slightly above the industry average. Although declining in the rankings since 2012, Hawaiian brought up its ranking from sixth in 2014 to fifth place in 2015 and 2016. Since 2014, Hawaiian increased its use of the more efficient Airbus A330-200, while decreasing its use of the older Boeing 767-300ER (ICCT, 2017). In 2014, 68% of Hawaiian's RPMs were flown by the A330-200 and 26% by the 767-300ER. By 2016, 78% of its RPMs were flown by the A330-200 while only 16% were flown by the 767-300ER.

Sun Country has also improved its fuel efficiency since the previous study, jumping from tenth place in 2014 to tie with United for the industry average in 2016. Between 2014 and 2016, Sun Country improved its load factor and increased its use of the larger Boeing 737-800. In 2014, Sun Country's load factor for its Boeing 737-700 was 71%, while by 2016 the load factor increased to 77%. Similarly, the load factor for Sun Country's 737-800 jumped from 73% in 2014 to 77% in 2016. Additionally, Sun Country began utilizing the 737-800 for more of its RPMs. In 2014, Sun Country's RPMs were split about 65% for the more efficient 737-800 and 35% for the less efficient Boeing 737-700. By 2016, the 737-800 accounted for 78% of Sun Country's RPMs. On average, Sun Country carried an average of 120 passengers per flight in 2016, a 7% increase from the 2014 average of 112 passengers.

Among the less-efficient carriers, Allegiant fell one place in the rankings since 2014. Allegiant's decline can be attributed to two factors: a 4% drop in overall load factor, and increased use of the smaller Airbus A319 (156 seats) in lieu of the larger Boeing 757 (215 seats). Allegiant intends to replace its fleet of aging, fuel-inefficient MD-80s with used Airbus A319s and A320s (Allegiant, 2017), so its fuel efficiency may improve as its fleet turns over. American Airlines has improved its fuel efficiency since 2014, moving from the least-efficient carrier in 2014 to eighth place in 2016. Part of this improvement is due to its merger with US Airways, which was the seventh most fuel-efficient carrier in 2014. Meanwhile, Delta has maintained its 2014 position at third from the bottom.

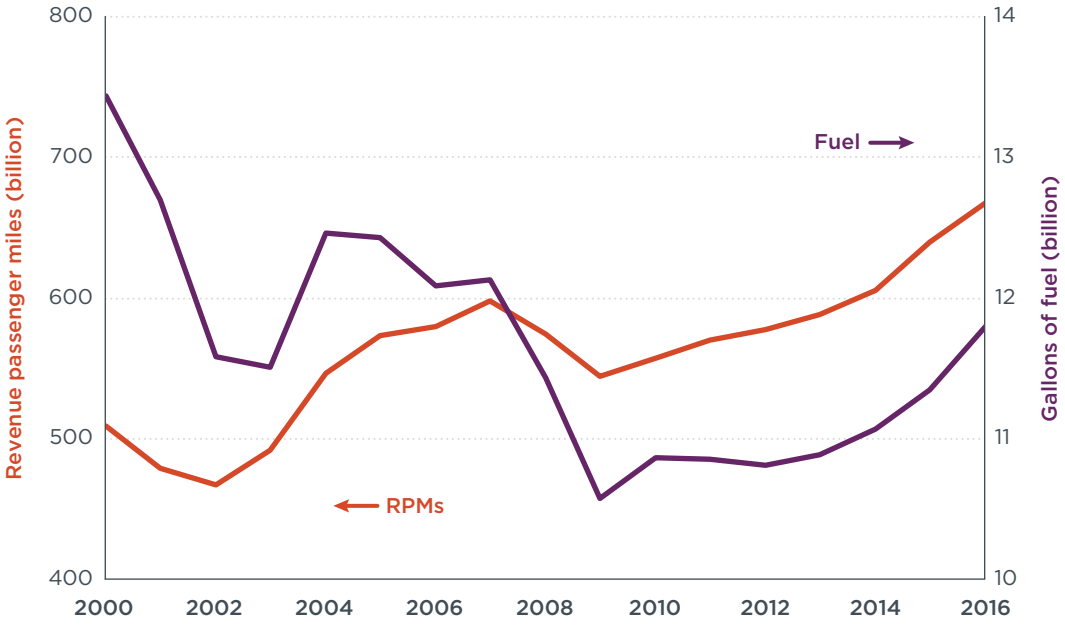
Finally, relative to its peers, Virgin America's fuel efficiency has continued to decline since 2012, reaching last place in 2015 and remaining there in 2016. This may be due to the carrier retaining a relatively static business model, while its competitors adopt strategies to increase their revenue and, correspondingly, their fuel efficiency on a passenger-mile basis. For example, on average, U.S. carriers increased their average seating densities[3] by 4% between 2010 and 2016, with some carriers (e.g. Frontier) increasing it by 13%. In contrast, Virgin America has increased its average seating density by only 1% since 2010, and continues to use single aisle Airbus A320 aircraft on cross-country routes on which other carriers would generally use larger aircraft.

On an RPM per gallon of fuel basis, Virgin America operated its A320s 14% to 15% less efficiently than the lead carrier using that aircraft type (Frontier), in part because the average Virgin America flight carried 30+ fewer passengers. Likewise, Virgin America's A319s carried 30 to 37 fewer passengers on an average flight than the lead carrier, incurring a 33% to 36% fuel efficiency penalty.

3 As measured by seats per square meter of Reference Geometric Factor, or RGF. RGF is a close proxy for the pressurized floor area of an aircraft, and was developed by the International Civil Aviation Organization as a means to assess aircraft fuel efficiency. See ICCT (2013) for further details.

3.3 INDUSTRYWIDE CHANGES IN DEMAND, FUEL EFFICIENCY, AND FUEL USE

The U.S. aviation industry continues to recover from the 2008 global financial crisis, aided in part by lower fuel prices. Domestic RPMs increased by 10% from 2014 to 2016, while fuel consumption increased by 7% (Figure 2).



Source: Form 41 data from Airline Data, Inc (2017).

Figure 2. Aviation demand and fuel use on U.S. domestic operations, 2000 to 2016.

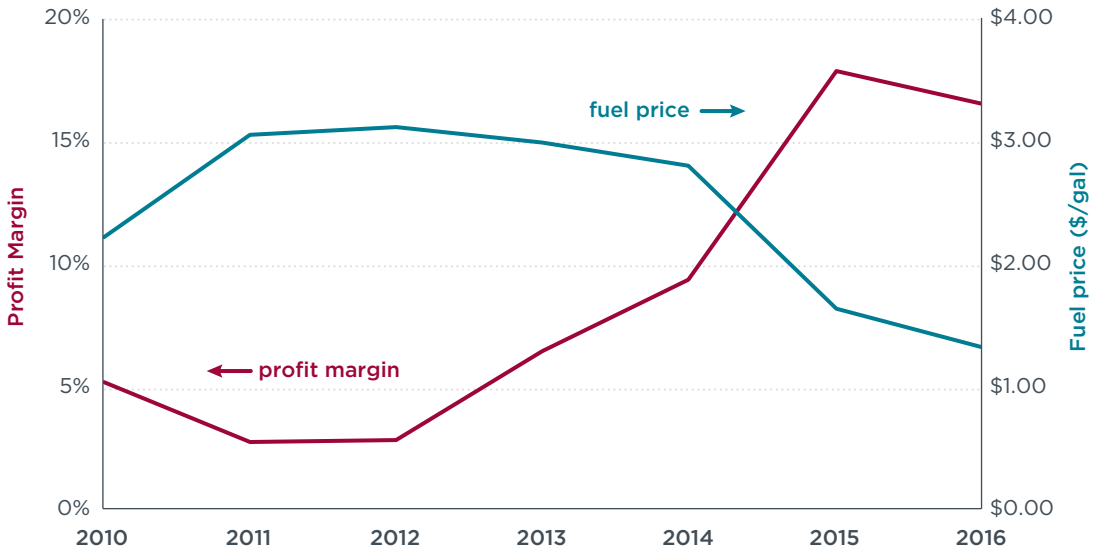
The strong increase in demand over the past two years outstripped efficiency gains. Overall, the efficiency of U.S. domestic operations improved by 3% from 2014 to 2016 on an RPM per gallon of fuel basis. This improvement was largely driven by an increase in the number of passengers per flight. By carrying more passengers over the same distance, air carriers can improve their efficiency in terms of RPMs per gallon of fuel.

Two variables influence the number of passengers carried: seating gauge, or the number of seats per aircraft, and load factor, or the percentage of seats filled on an average flight. Between 2014 and 2016 the average seating gauge of the domestic U.S. fleet increased by about 3%, largely owing to increases in seating density rather than the use of larger aircraft. Load factor, in contrast, remained constant at 84%.

However, not all airports are treated the same when it comes to travel growth and connectivity. While mobility (RPMs) expanded rapidly, total departures increased only modestly—0.8%. Therefore, access to air services, as measured by the number of airports served or flight frequency, changed very little. Overall, 95% of the growth in enplanements from 2014 to 2016 occurred at the largest 60 U.S. airports, with no net growth in the smallest 390 airports (FAA, 2017b). Thus, the bulk of the fuel-efficiency gains observed over the past two years were linked to moving more people between medium- and large-sized aircraft hubs.

3.4 PROFITABILITY, FARES, AND FUEL COSTS

Following the collapse of jet fuel prices in 2014, U.S. carriers saw record profit margins for 2015 and 2016 (Figure 3). Profits have grown consistently from 2012 to 2015, leading Doug Parker, the Chairman and CEO of American Airlines, to say, "We have an industry that's going to be profitable in good and bad times. I don't think we're ever going to lose money again" (Koenig, 2017). In 2014, the industry average profit margin was 9%, while in 2015 and 2016 it grew to 18% and 17%, respectively. In 2016 alone, U.S. carriers made nearly $20 billion on domestic operations.

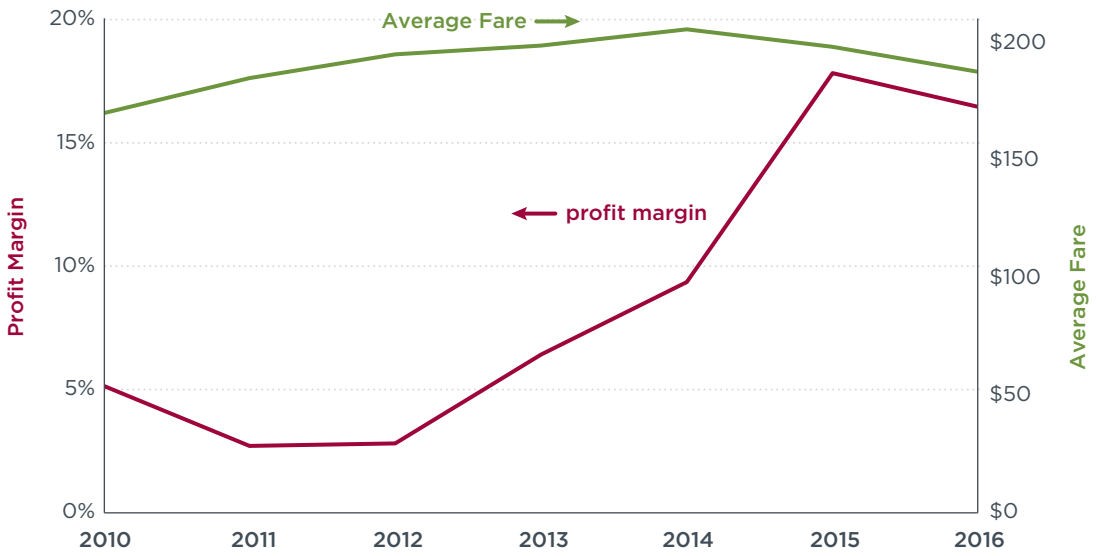


Sources: EIA, 2017; Airline Data, Inc (2017).

Figure 3. Profit margin and fuel costs, 2010–2016.

Since fuel prices peaked in 2012, the average profit margin for mainline domestic carriers has increased nearly sixfold, from 2.8% in 2012 to 16.6% in 2016, due to lower fuel prices and higher ancillary fees.[4] This corresponds to an increase in profit from $2.9 to $19.4 billion. Lower fuel prices accounted for most of that gain. Compared to 2012 prices, lower fuel expenditures saved mainline U.S. airlines about $17 billion on domestic routes. Meanwhile, passenger fares decreased by about 4%, or the equivalent of $3.1 billion, in comparison to 2012 fares (Figure 4). Thus, approximately 20% of fuel savings over this period translated to lower fares for travelers.

4 Ancillary fees grew from 10% of overall revenue in 2011 to 16% in 2016. See Appendix B for further details.



Source: Form 41 and DB1B data from Airline Data, Inc (2017).

Figure 4. Average profit margin and average fare for mainline U.S. domestic airlines, 2010-2016.

4. CONCLUSIONS

This study assessed the fuel efficiency of U.S. airlines on domestic operations in the years 2015 and 2016. Four carriers—Alaska, Spirit, Frontier, and Southwest—had fuel efficiency scores considerably above the industry average in both years. Alaska has the distinction of being the most fuel-efficient carrier for the past seven years (2010 to 2016). In 2016, Frontier overtook Spirit to place second after increasing its use of the A321. After a consistent decline, Hawaiian improved its standing to reach fifth place in 2016. Following its merger with US Airways, American improved from last place in 2014 to reach eighth place in 2016. Virgin America was the least efficient airline in both 2015 and 2016. In 2018, the most and least fuel-efficient air carriers—Alaska and Virgin America—will merge, potentially causing a large shift in the overall ranking.

The fuel-efficiency gap between the most-efficient and least-efficient airlines increased slightly from 25% in 2014 to 26% in 2016. On average, the fuel efficiency of U.S. domestic operations improved by 3% on an RPM per fuel basis. In contrast, RPMs increased by 10% from 2014 to 2016, leading to a 7% increase in overall fuel consumption. This sharp increase raises questions about how the U.S. aviation industry can meet its goal of carbon-neutral growth from 2020 without further policy interventions.

Airline profit margins also grew rapidly, from 3% on average in 2012 to 17% on average in 2016. Overall, U.S. airlines made almost $20 billion in 2016, up from only $3 billion in 2012. Lower fuel prices accounted for most of that gain. Growth in U.S. traffic was concentrated in major markets, while smaller and regional airports saw no net growth in aviation services.

Looking ahead, as industry consolidation increases—for example, through the Alaska-Virgin America merger—we expect corresponding changes in the relative fuel efficiency of the remaining carriers. Likewise, continued expansion by ultra-low-cost carriers, like Spirit and Frontier, may have large implications for fleetwide efficiency. Finally, the introduction of new, more efficient singe aisle aircraft types like the Airbus A320neo, Boeing 737 MAX, and Bombardier CSeries should influence the efficiency of early adopters.

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APPENDIX A. 2015 RESULTS

Table A1. FES and excess fuel per unit transport service for U.S. domestic carriers, 2015.

Rank	Airline	FES	Excess Fuel Per Unit Transport Service
1	Alaska	1.13	—
2	Spirit	1.11	+2%
3	Frontier	1.08	+5%
4	Southwest	1.07	+6%
5	**Hawaiian**	**1.00**	**+13%**
5	**United**	**1.00**	**+13%**
7	Sun Country	0.97	+17%
8	Delta	0.95	+19%
9	Allegiant	0.94	+21%
9	American	0.94	+21%
9	JetBlue	0.94	+21%
12	Virgin America	0.92	+23%

Table 1 above shows the 2015 airline ranking by most to least efficient carrier. Alaska remained the most fuel-efficient U.S. domestic carrier in 2015. Spirit and Frontier took second and third positions, while Southwest came in a close fourth place. Hawaiian and United tied for fifth place and represent the industry average for fuel efficiency. Sun Country, Delta, Allegiant, American, and JetBlue form the below-average cohort of air carriers, burning 17% to 21% more fuel than the leading carrier. Virgin America was the least efficient carrier, burning 23% more fuel than Alaska. The gap between most and least efficient airlines was 23%, slightly smaller than the 24% difference in 2014.

APPENDIX B. ANALYSIS OF PROFITABILITY ON U.S. DOMESTIC OPERATIONS

A breakdown of profit margin by air carrier is provided in Table 3. In both 2015 and 2016, Allegiant led as the most profitable airline, followed by Alaska. Allegiant has a unique business model among U.S. domestic carriers. It only provides leisure service, usually connecting small regional airports to vacation destinations. It also garners much of its revenue not through tickets but rather from hotel and car reservations. Starting in 2016, Allegiant began to replace its MD-80 fleet with used Airbus A319s and A320s (Allegiant, 2017), in an attempt to improve efficiency and reliability after the company was plagued with safety incidents. As the company continues to purchase Airbus aircraft, overall profitability may initially decline as costs increase over the next few years.

Table B1. Profit margins, 2010–2016, by air carrier.

	Profit Margin						
	2010	2011	2012	2013	2014	2015	2016
Airtran	5%	-1%	-1% (Q1)	—	—	—	—
Alaska	14%	12%	13%	17%	18%	23%	25%
Allegiant	14%	9%	12%	14%	13%	29%	26%
American	1%	-6%	-2%	3%	10%	17%[1]	14%
Continental	-9%	-7%	—	—	—	—	—
Delta	11%	11%	8%	8%	7%	19%	17%
Frontier	-2%	-9%	1%	0%	13%	16%	19%
Hawaiian	7%	-1%	4%	15%	16%	23%	26%
JetBlue	6%	3%	4%	5%	5%	15%	17%
Southwest	8%	5%	4%[1]	7%	12%	21%	18%
Spirit	9%	15%	13%	17%	18%	24%	19%
Sun Country	5%	-2%	3%	4%	3%	3%	3%
United	3%	1%	-4%[1]	2%	4%	13%	15%
US Airways	5%	3%	5%	6%	13%	18% (Q1,Q2)	—
Virgin America	0%	-1%	-2%	6%	6%	12%	12%
Industry Average	**5%**	**3%**	**3%**	**6%**	**9%**	**18%**	**17%**

[1] Year when mergers are first reflected in an airlines profitability.

Frontier has seen the greatest growth in profit margin, from a small loss in 2010 to matching Spirit as the third most profitable carrier in 2016. Frontier's increased profit margin aligns with its reorganization as an ultra-low-cost carrier (ULCC) in 2014 to include more ancillary fees. Sun Country continued to be the least profitable airline from 2014 through 2016. However, in 2017, Sun Country hired former Allegiant COO Jude Bricker as company CEO. Bricker has announced his intention to improve profitability by overhauling Sun Country's operations to mirror those of other ULCCs, like Allegiant and Frontier (Wilson, 2017).

In recent years, more and more air carriers have bolstered their bottom lines through the increased use of ancillary fees. These fees include a la carte features such as meals, seat selection, blankets, and WiFi, along with baggage and cancellation fees. They also include commission-based products such as hotel and rental car reservations, travel insurance, frequent flyer programs, and advertising. In 2011, ancillary fees accounted for about 10% of revenue, on average, across U.S. carriers. By 2016, this average grew to 16%, as shown in Figure B1. It is even more prevalent in low-cost carriers[5]; on average low-cost carriers in 2016 garnered 20% of their annual revenue from ancillary fees. In 2016, ancillary fees accounted for 40% or more of the annual revenue for ULCCs Allegiant, Frontier, and Spirit.

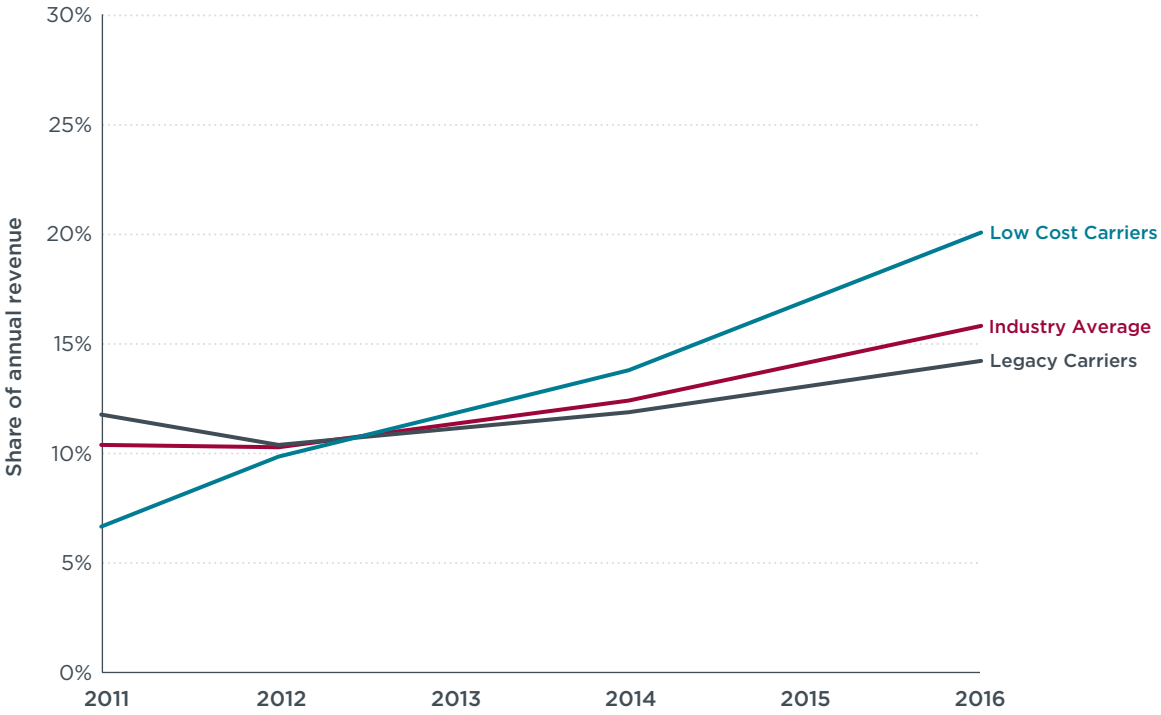

Figure B1. Percent of mainline annual revenue attributable to ancillary fees, 2011-2016. (Sorensen, 2017)

5 Low-cost carriers include Spirit, Frontier, Southwest, Sun Country, Allegiant, and Virgin. Legacy carriers include Alaska, Hawaiian, United, Delta, American, and JetBlue.