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U.S. DOMESTIC AIRLINE FUEL EFFICIENCY RANKING, 2013

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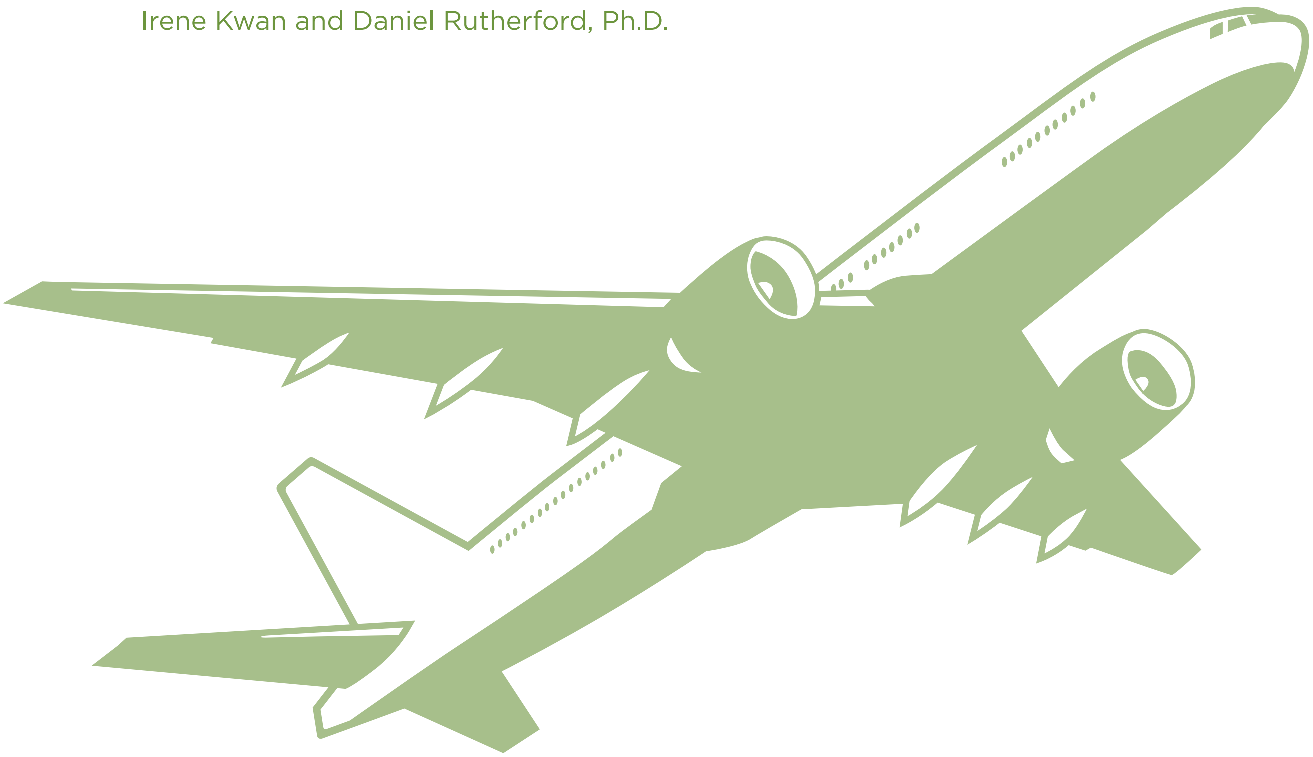

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1. INTRODUCTION

Aircraft play a vital role in our modern economy by quickly and conveniently transporting goods and people, although at a cost to the global climate. The environmental impact of air travel is a growing concern in light of the threats to public health related to climate change, including extreme weather events and the emergence of disease (Chan, 2014). If counted as a country, global aviation would have ranked seventh in terms of CO_2 emissions in 2011, just after Germany and well ahead of Korea (International Energy Association, 2013; International Air Transport Association, 2013). Moreover, aviation CO_2 emissions are projected to triple by 2050 under business-as-usual scenarios (Lee et al., 2013). CO_2 emissions from U.S. domestic flights account for about one-quarter of the global total from commercial aircraft (Environmental Protection Agency, 2008) and are expected to grow an average of 1% per year over the next 20 years, increasing from 116 million metric tons (MMT) of CO_2 in 2014 to about 143 MMT by 2034 (Federal Aviation Administration, 2013).

U.S. and international policymakers are moving to address the aviation emissions challenge. Environmental groups represented by Earthjustice petitioned (2007) and then sued (2010) the U.S. Environmental Protection Agency (EPA) for delay in regulating U.S. aviation emissions under the Clean Air Act (CAA). In 2011 the court ruled that EPA must move to address emissions from aircraft (Center for Biological Diversity, 2011). EPA has set out a timeframe for a draft "endangerment" finding in April 2015 on whether greenhouse gas emissions from aircraft endanger public health or welfare (EPA, 2014), with a final determination expected by spring 2016. A positive finding would trigger domestic regulatory action. At the international level, the International Civil Aviation Organization (ICAO), the de facto regulator of airlines worldwide, is working to develop a CO_2 standard for new aircraft and a global market-based measure framework for in-service aircraft by 2016.

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 makes up 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 September 2013 and then again in April 2014 the International Council on Clean Transportation (ICCT) released reports comparing the fuel efficiency of major U.S. airlines on domestic operations in 2010 and 2011–2012, respectively (Zeinali, Rutherford, Kwan, & Kharina, 2013; Kwan, Rutherford, & Zeinali, 2014). The studies applied a methodology developed by the University of California, Berkeley, National Center of Excellence for Aviation Operations Research (NEXTOR) to assess and compare the relative fuel efficiencies of airlines irrespective of size, operational structure, and business model (Zou, Elke, & Hansen, 2012).

This paper updates the information provided in those earlier reports on the fuel efficiency of U.S. airlines with data and analysis for their 2013 domestic operations.

Key findings include:

1. The fuel efficiency gap between the most and least efficient airlines widened slightly to 27% in 2013.
2. Alaska and Spirit, joined by Frontier Airlines, were the most fuel-efficient airlines in 2013 due to superior technology and operational efficiencies.
3. Overall, there was no net gain in the fuel efficiency of U.S. operations from 2012 to 2013, due to the stagnating fuel efficiency of other carriers, notably American Airlines.
4. There continues to be no clear correlation between airline profitability and efficiency, despite all 13 major U.S. domestic carriers being profitable in 2013.

2. METHODOLOGY

This section provides a brief overview of the approach used to evaluate relative airline fuel efficiencies in this study. Additional detail regarding the methodology can be found in Zou et al. (2012).

2.1 FRONTIER APPROACH

This update, like previous studies, uses a frontier model to evaluate and compare the fuel efficiency of U.S. airlines on domestic operations. This approach enables an equitable comparison of airline fuel efficiency, regardless of business model, through the use of primary fuel burn data and an inclusive metric for transport service—a combination of mobility, measured by revenue passenger miles (RPM), and access, measured by departures (number of airports served or flight frequency). 2013 quarterly-reported traffic and fuel data provided by Data Base Products (2014), a reseller of Form 41 U.S. air carrier data from the U.S. Department of Transportation's Bureau of Transportation Statistics (BTS), was used to develop a statistical frontier model that normalizes each airline's fuel consumption by the transport service it provides. The model relates the input, fuel, of an airline *i* at time *t* to its output, revenue passenger miles (RPM) and departures (dep):

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

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

Assuming that a log-linear function best describes the dataset, Equation 1 is transformed into the following functional form:

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

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. The approach also recognizes the need to account for regional carriers, which operate a significant portion of flights for some mainline airlines. Regional carriers were incorporated through the apportionment of their RPMs, departures, and fuel to corresponding mainline carriers using BTS Airline Origin and Destination Survey data (DB1B). Circuity, the degree to which airlines deviate from direct flight paths due to one or more layovers that require extra distance traveled, was also accounted for. The resulting frontier model representing 2013 airline fuel consumption, with standard error in parentheses, was:

$$\underset{}{ln(fuel)} = \underset{(0.869)}{-2.279} + \underset{(0.063)}{0.817}*ln(RPM) + \underset{(0.052)}{0.215}*ln(dep) \qquad \textbf{[Eq. 3]}$$

Number of observations: 52 $\qquad R^2 = 0.996$

A unitless fuel efficiency score (FES), measuring the transport service (combination of mobility and access) an airline provides per unit of fuel consumed, is calculated by normalizing each airline's inefficiency value (calculated based on Eq. 3) by the simple average across all airlines. A higher FES indicates relatively higher fuel efficiency—that is, a high-scoring airline consumes less fuel per unit of transport service than airlines with a lower FES.

3. FINDINGS

The fuel efficiency scores for U.S. domestic carrier operations by airline in 2013 are shown in Figure 1. An FES of 1.00 represents the industry average fuel efficiency in 2013, with a higher FES score denoting an airline with better fuel efficiencies than the norm, and scores lower than 1.00 indicating an airline with below average efficiency on U.S. operations.

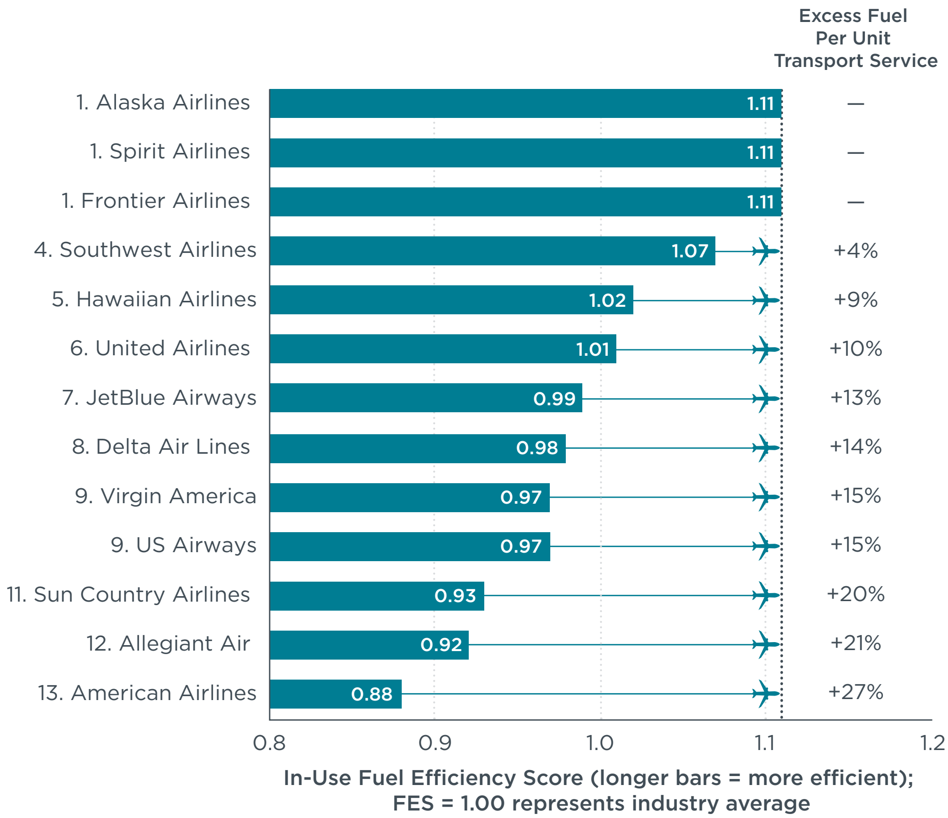

Figure 1. Fuel Efficiency Scores by airline for U.S. domestic operations in 2013

In 2013, Alaska Airlines, a legacy carrier based in the Pacific Northwest, tied with Spirit and Frontier, two ultra low-cost carriers, in overall fuel efficiency with an FES of 1.11. Southwest Airlines, in fourth place with an FES of 1.07, burned about 4% more fuel than Alaska, Spirit, and Frontier to provide a comparable level of transport service. Hawaiian Airlines, which ranked third in efficiency in 2010, has been falling relative to its peers and was ranked fifth in 2013. United Airlines, which completed its merger with Continental Airlines in 2012, continues to be the most efficient full-service U.S. carrier, performing just above the 2013 industry average with an FES of 1.01.

In 2013, JetBlue Airways had slightly lower fuel efficiency than the industry average, with an FES of 0.99. Following behind JetBlue is Delta Air Lines, which burned about 14% more fuel than the top airlines on comparable operations. As in 2012, Virgin America and US Airways were tied for ninth place. Sun Country Airlines, Allegiant Air, and American Airlines, the three least-efficient carriers in 2013, all burned at least 20% more fuel per unit transport service than the industry leaders. Notably, Allegiant's fuel efficiency improved in 2013, from 26% below the top airline in 2012 to only 22% in 2013. American Airlines, now the largest airline for domestic operations after its merger with US Airways in early December 2013, came in last place with an FES of 0.88. The gap between the least and most efficient airlines widened to 27%, compared to 26% in 2012.

3.1 KEY AIRLINE FINDINGS

The airline fuel efficiency rankings for 2010 to 2013 are shown in Table 1, which also highlights the shifts in ranking over time. Due to the United-Continental and Southwest-AirTran mergers (as indicated by the arrows), the total number of airlines in the study dropped from 15 in 2010 to 13 in 2012.

Table 1. Airline fuel efficiency rankings for U.S. domestic operations, 2010–2013

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

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

Since 2010 Alaska and Spirit continued to have the most efficient U.S. operations due to their more fuel-efficient fleets and efficient operational practices (e.g., higher seating densities and load factors). In 2013 Alaska flew an increasing percentage of its RPMs on Boeing 737-800 and 737-900 aircraft, and its regional flights on fuel-efficient Dash 8 turboprop aircraft via its affiliate partner Horizon Air. Spirit continues to make aircraft improvements through the use of new A320s with Sharklets, which reduce fuel use by up to 4% (Spirit, 2013). A typical Spirit A320 aircraft carries up to 36 more people on a flight than on a similar aircraft flown by its rivals, and flew 34% more passenger miles per pound of fuel compared to the least efficient airline in 2012 (Kwan, Rutherford, & Zeinali, 2014). Both Alaska and Spirit have relatively young fleets and fly with passenger load factors averaging over 85%.

Frontier leapfrogged Southwest and Hawaiian to tie for first with a 10% fuel efficiency improvement from 2012 to 2013. In 2012, Indigo Partners, a private equity firm, purchased Frontier and has been transforming the airline into an ultra low-cost carrier (Business Wire, 2013). Significant changes were made to its fare structure (Mutzabaugh, 2014) as well as flight operations. Frontier reduced its total flights by about 33% as well as its regional affiliate operations from 14% of its total RPMs in 2012 to only 3% in 2013, in doing so shifting flights from less efficient regional jets to larger, more efficient Airbus aircraft. Moreover, Frontier's load factor improved to 91%, the highest on U.S. domestic operations, thereby transporting more passengers on an average flight. Since 2011, it also began to phase out its less efficient Airbus A318 aircraft, for which it served as a launch customer, for larger A319 and A320 aircraft.

In 2012 Allegiant and American tied for having the least-efficient U.S. domestic operations. Since then Allegiant has made significant improvements, while American's fuel efficiency actually worsened. Though still flying a majority of its flights on older MD-80 aircraft, since 2011 Allegiant has been adding second-hand Boeing 757-200, Airbus A320 and A319 aircraft to its fleet for higher capacity and longer range (Mutzabaugh, 2012). On an average flight in 2013, Allegiant used aircraft that were 7% larger with a 6% higher overall seating density than in 2012, translating to 12 more seats on an average flight. American's fuel efficiency, on the other hand, declined by about 1.5% from 2012 to 2013, leading it to burn 27% more fuel to deliver a comparable level of transport service than the top three airlines in 2013. Although it has been flying a greater proportion of its RPMs on Boeing 737-800's rather than on older MD-80 aircraft, American still has the third oldest fleet (after Allegiant and Delta).

Other notable airlines include Hawaiian, whose FES has slipped in recent years as other airlines continue to improve. Hawaiian made changes to its flight operations including flying almost 50% of its RPMs on newer A330-200 aircraft (introduced in 2010) and 42% on older Boeing 767-300ER aircraft, compared to 37% on A330-200 and 54% on B767-300ER aircraft in 2012. However, the greater use of A330-200 aircraft made little apparent improvement in Hawaiian's overall efficiency. Southwest shifted down to fourth as Frontier moved up to third in 2013, although Southwest continued to make some efficiency improvements even after its merger with much less efficient AirTran Airways in 2012. JetBlue was ranked seventh in fuel efficiency during the entire period from 2010 to 2013, with its fuel efficiency being slightly above that of the industry average in 2010, at the industry average in 2011 and 2012, and falling slightly below average in 2013. One possible reason for JetBlue's drop is an increase in non-direct flights, as indicated by an increase in circuity from 2012 to 2013. Moreover, while other airlines are moving up in efficiency due to aircraft and/or operational improvements, JetBlue's operations appeared more or less constant over time. [1]

3.2 AIRLINE INDUSTRY FINDINGS

Industry-wide fuel efficiency improvements on U.S. domestic operations continued to slow in 2013. Figure 2 plots the average transport service per fuel consumption (unnormalized FES) for all domestic passenger carriers (light blue line), along with that of selected airlines (colored lines) over the past 20 years and since 2010, respectively.[2] The shaded grey region is an approximate range of mainline airline efficiency for years prior to 2010.[3]

1 JetBlue flew 84% of its RPMs on Airbus A320 aircraft and 16% on Embraer 190 aircraft every year from 2010 to 2013. In 2013, JetBlue added four new A321 Sharklet aircraft to its fleet, but these accounted for less than 0.1% of its total RPMs.

2 Calculated using mainline carrier data and a transport service per fuel ratio based on 2013 frontier model coefficients: $\frac{rpm^{0.817}\ dep^{0.215}}{fuel}$.

3 The upper and lower bounds of the shaded grey region are three-year moving averages and approximate the fuel efficiency of the most and least efficient mainline carriers in a given year prior to 2010.

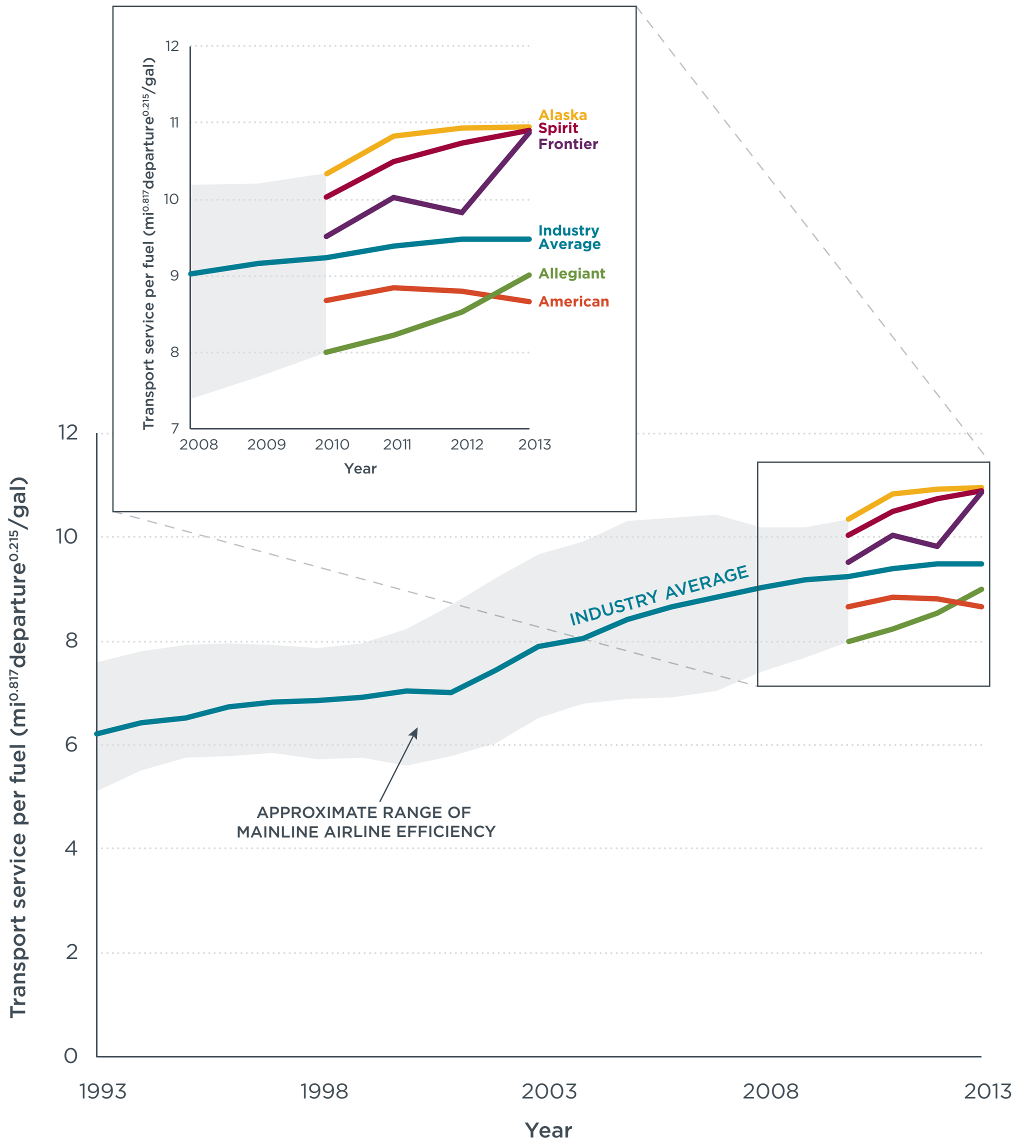

Figure 2. Transport service per fuel for select U.S. domestic airlines, 1993–2013

Figure 2 demonstrates that on average there was no net improvement in the fuel efficiency of U.S. domestic operations from 2012 to 2013. As shown by the rising blue line, with the notable exception of 2001 when U.S. aviation was disrupted by the 9/11 terrorist attacks, the previous two decades have seen relatively large improvements in average fuel efficiency—about 49%, or 2.4% annually—between 1993 and 2010. In contrast, the fuel efficiency of U.S. operations improved only 1.3% per year from 2010 to 2012, with no improvement the following year. Although airlines like Frontier and Allegiant are making strides in reducing their fuel consumption, they are relatively small carriers. Other airlines such as American show little improvement, or even backsliding, in efficiency. These slowing gains are linked to a lack of new, more efficient aircraft types, the time lag between new aircraft delivery and penetration into the in-use fleet, and the diminishing gains from increasing load factors (Rutherford, 2014).

Even as efficiency gains slow over time, airlines are increasingly profitable on U.S. domestic operations (Figure 3).

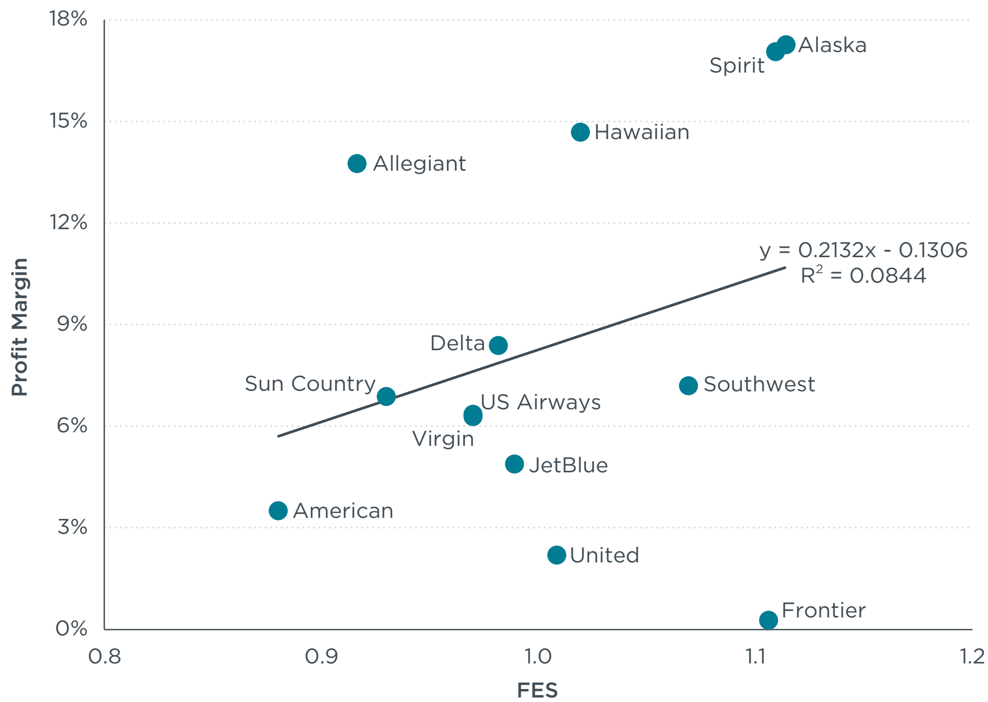

Figure 3. Net operating profit margin on U.S. domestic operations and FES in 2013, mainline airlines

As Figure 3 demonstrates, there was little apparent correlation between airline profitability and fuel efficiency in 2013, suggesting that fuel cost alone is not sufficient to drive significant efficiency improvements. This profitability, combined with the falling rate of fuel efficiency improvements in recent years, raises questions about the degree to which U.S. airlines will continue to invest in newer, more fuel-efficient aircraft. This research suggests that in order for the U.S. aviation industry to meet its goal of carbon neutral growth from 2020, business-as-usual technology and operational improvements will likely need to be promoted via policy instruments, including an aircraft CO_2 standard (Rutherford & Zeinali, 2009) and market-based measures to put a price on carbon emissions from the aviation sector.

4. CONCLUSIONS

This study analyzed the fuel efficiency of U.S. domestic operations in 2013 and described how the efficiencies of individual airlines have changed since 2010. Alaska and Spirit continued to lead in fuel efficiency, while Frontier's large 10% improvement in 2013 allowed it to leapfrog Southwest and Hawaiian to tie for first with Alaska and Spirit. At the other end, despite aggressive goals for fleet renewal, including a firm order of 100 A321neo and 100 Boeing 737 MAX aircraft (to be delivered by 2021 and 2022, respectively),[4] American is being left behind in the fuel efficiency race. On balance, industry-wide efficiency stagnated in 2013, with no net improvement last year. Improving carriers tended to be small and balanced out by the relative lack of progress by the larger legacy carriers. In contrast, all major U.S. domestic carriers were profitable in 2013.

This report found no net improvement in fuel efficiency between 2012 and 2013, raising questions about the link between fuel efficiency and profitability and the degree to which U.S. airlines will continue to invest in fuel efficiency as fuel prices moderate or even drop (U.S. Energy Information Administration, 2014). These findings should be of interest to policymakers looking for solutions—for example, a CO_2 emission standard and market-based measures—to help meet U.S. domestic and global climate protection goals. In 2014, future work will investigate the short-term effects of the American-US Airways merger, which created a huge new airline that will heavily influence the fuel efficiency of the U.S. aviation sector.

4 Ascend Fleets 2014.

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