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Does Size Matter in the Airline Industry?

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ABSTRACT

Over the last decade, the U.S. airline industry has transformed itself through mergers, restructurings, bankruptcies, and dissolutions. Also during this time, the airline industry focused on a business model that was driven by an emphasis on asset utilization. This was driven by increasing the load factor to increase cost efficiencies through economies of scale so that the return on invested capital could be improved by reducing the operating costs. This study evaluates economies of scale and resultant cost efficiencies in the U.S. passenger airline industry for the period 2013 to 2018. The research finds that the airline industry is experiencing cost efficiencies with every increase in the size of the airline, but cost efficiencies are not evenly distributed. The paper also finds that the main source of cost efficiency appears to be aircraft maintenance expenses.

INTRODUCTION

This study evaluates economies of scale in the U.S. airline industry over the period of 2013 to 2018. Commercial aviation has a direct impact on our nation's economy, creating more than 10 million well-paying American jobs and driving 5 percent of the U.S. gross domestic product and nearly $1.7 trillion in annual economic activity.[1] The airline industry in the United States has undergone transformational changes within recent decades with several mergers, acquisitions, bankruptcies and restructurings. A spate of mergers that completely changed the competitive landscape of the U.S. airline industry occurred in the period around 2008-2016. A major event occurred on October 31, 2010, when UAL Corp., parent company of United Airlines, and Continental Airlines Inc. completed their merger, creating United Continental Holdings Inc. Other important deals include the merger of Delta Air Lines and Northwest Airlines Corp. in 2008, the acquisition of AirTran Holdings Inc. by Southwest Airlines for $1.4 billion in cash and stock in May 2011, and the $3.0 billion purchase of Virgin America by Alaska Air Group in December 2016.

During this process of restructuring and reorganization, the airline industry has learned that market share alone is not enough to survive and compete in this highly competitive market. Instead, they also need profitability by emphasizing and obtaining a better rate of return on capital through improvement in load factor and cost efficiencies. The goal of this new emphasis on profitability and a better rate of return is to focus on cost reduction with the goal of earning a rate of return that is higher than the cost of capital so that these decisions add long-term value to the company. Mergers and acquisitions in the U.S. airline industry have been driven by this desire to reduce costs and improve the rate of return.

According to Federal Aviation Administration (FAA), the U.S. commercial aviation industry consisted of six airlines that control about 85% of the commercial market in November 2017. These airlines are Alaska Air Group Inc. (which completed its merger with Virgin America Inc. in December 2016), American Airlines Group Inc., Delta Air Lines Inc., Jet Blue Airways Corp., Southwest Airlines Co., and United Continental Holdings Inc. The rationale for these mergers was that it will help airlines attain cost efficiencies through economies of scale and earn a superior rate of return on their capital.

In this study, we evaluate cost efficiencies of these six major airlines in the U.S. passenger airline

[1] Source: https://www.airlines.org

industry over the past six years from 2013 to 2018. The study is important for several reasons.
First, we are not aware of any study that evaluates cost efficiencies of the major airlines in the United States. Secondly, in the wake of the mergers and restructurings, size and scale have become more important than ever. The U.S. airlines industry has fewer competitors and less capacity chasing customers, which should help the industry to be more disciplined on capacity, so airlines can price their product in a way that generates a sustainable return on invested capital.

Finally, the industry will help regulators understand the impact of mergers on the cost reduction and profitability of companies. Companies usually argue that they need to merge, because it help them improve their operating efficiency and profitability. Also, if mergers reduce operating costs and airlines are able to operate at a lower cost then some of this cost savings should be passed on to consumers in the form of lower ticket prices.

The rest of this paper is organized along the following lines. The first section summarizes previous studies. The second section discusses the model used in this study. Data and methodology are discussed in the following section. The next section provides a discussion of the empirical findings. The final section summarizes and concludes this study.

LITERATURE REVIEW

There have been several studies on economies of scale in different industries, but few studies have specifically focused on the U.S. airline industry. Johnston and Ozment (2013) investigated economies of scale in the U.S. airline industry using annual data from 1987 to 2009. They found that the U.S. airline industry operated under modest economies of scale. The study reported that, on average, the largest major U.S. airlines have enjoyed increasing returns to scale for the previous 22 years. Caves, Christensen, and Tretheway (1984) studied economies of scale for the U.S. airline for the period 1970-1981. They found that small airlines have a higher cost, but differences in scale did not explain the higher cost for smaller airlines. They concluded that density of traffic within an airline's network is responsible for explaining cost differences among airlines. Creel and Farell (2001) evaluated economies of scale in the U.S. airline industry after deregulation of the airline industry. They analyzed the cost structure of the US airline industry after deregulation and found that there were economies of scale at moderate levels of output. They concluded that due to the existence of economies of scale, airlines will try to grow to the efficient size.

Seong-Jong & Fowler (2014) used data envelopment analysis for measuring the relative efficiency of 90 airlines in Asia, Europe, and North America. They found that the efficiency of the airlines in Europe is the lowest among the airlines in these three regions. Min & Min (2015) developed a set of target performance standards that help airlines monitor their service delivery process, identify relative weaknesses, and take corrective actions for continuous service improvements. Wu & Ying-Kai (2014) used an integrated DEA-BSC model to evaluate the operational efficiency of 38 major airlines across the world to evaluate their relative performance. The study indicated that airlines with excellent performance in the efficient frontiers tended to perform better in energy, capital, and other operating costs. Carastro (2010) emphasized the use of non-financial measures to evaluate the airline industry. Assaf & Josiassen (2011) measured the technical efficiency of U.K. airlines through by using data envelopment analysis (DEA) bootstrap methodology. They reported that the efficiency of UK airlines has continuously declined since 2004 to reach a value of 73.39 per cent in 2007. Factors which were found to be significantly and positively related to technical efficiency variations included airline size and load factor. Schefczyk (1993) studies 15 airlines by using data envelopment analysis as a technique to analyze and compare operational performance of airlines. The study concluded with an analysis of strategic factors of high profitability and performance in the airline industry.

In this paper, we extend previous studies by examining cost efficiencies U.S. airlines. To our knowledge, no study has examined the operating efficiency of the U.S. airlines since the shakeup of the airline industry in the United States.

MODEL

To evaluate economies of scale in the airline industry, we estimate the coefficients of a translog cost function to determine which factors contribute to economies of scale and their degree of contribution. We then estimate cost elasticity with respect to the amount of output (output is being measured in two different methods: total assets and total revenue) using the first derivative of the translog cost function. Cost elasticity is estimated for the total sample for each year.

In order to investigate economies of scale in the airline industry, we use a two-part methodology. The first part is an estimation of coefficients for a translog cost function to determine which factors contribute to economies of scale and the extent to which they contribute for each of the five years in the period 2013 to 2018. We estimate economies of scale for total operating expenses of an airline and also with respect to each component of the total operating expenses, namely salary & benefits, aircraft fuel, station operations, maintenance & repairs, sales & marketing, and aircraft lease rentals.

The second part is an estimation of coefficients for a translog cost function using the panel data approach. The panel data approach allows for pooling of observations on a cross-section of U.S. airlines over five years. When observations possess the double dimension (cross section and time series), the crucial aspect of the problem is to have a clear understanding of how differences in behavior across individuals and/or through time could and should be modeled. A panel data set offers several econometric benefits over traditional pure cross section or pure time series data sets. The most obvious advantage is that the number of observations is typically much larger in panel data, which will produce more reliable parameter estimates and, thus, enable us to test the robustness of our linear regression results. Panel data also alleviates the problem of multicollinearity, because when the explanatory variables vary in two dimensions (cross-section and time series), they are less likely to be highly correlated. Panel data sets make it possible to identify and measure effects that cannot be detected in pure cross section or time series data. For instance, sometimes it is argued that cross section data reflect short-run behavior, while time series data emphasize long-run effects. By combining the cross-section and time series features of a data set, a more general and comprehensive dynamic structure can be formulated and estimated. The use of panel data suggests that individuals, firms, states, or countries are heterogeneous (Balestra 1995). Time series and cross-section studies not controlling for this heterogeneity run the risk of obtaining biased results (Baltagi 2000). Panel data controls for individual heterogeneity.

The most intuitive way to account for individual and/or time differences in the context of panel data regression is to use the fixed effects model. The fixed effect model assumes that difference across airlines can be captured in differences in the constant term. The regression coefficients (the slope parameters) across groups in this model are unknown, but fixed parameters. It is also known as the least square dummy variable (LSDV) model and we use the LSDV fixed-effect model to estimate cost efficiencies in the airline industry.

Translog Cost Function

In financial economics, the translog model is the most pervasive approach for investigating economies of scale. The translog cost model implicitly assumes a U-shaped average cost function. It is used here because it allows economies of scale to vary with level of assets.

The estimation of scale economies with a translog cost function requires cost and output measures. For the airline industry, the output in this paper has been defined in terms of

· Total assets of the airline
· Total revenue of the airline

Total operating cost of each airline is defined as the total cost of operating an airline that includes wages & benefits expenses, aircraft fuel, aircraft maintenance, aircraft rent, landing fees & other rentals, contracted services, selling expenses, depreciation & amortization expense, food & beverage service expense, other operating expenses. An airline's total operating expense is modeled as a function of total assets and control variables that affect level of expenses.

We use a translog cost function to estimate economies of scale in the airline industry. Ordinary least squares (OLS) regression is used to find coefficients of the independent variables. Equation 1 shows the translog cost function to estimate economies of scale for the airlines with respect to total output (See Latzko, 1999):

$$\text{Ln COST} = ß_0 + ß_1 \text{ ln TOTAL OUTPUT} + ½\, ß_2 (\text{ln TOTAL OUPUT})^2 + Ó_j\, ß_j X_j + e \qquad (1)$$

In the translog function, the definition of COST depends on the input variable with respect to which one we are computing economies of scale. Therefore, cost can be the dollar amount of a company's total operating expenses and each component of the total operating expenses that includes salary & benefits, aircraft fuel, station operations, maintenance & repairs, sales & marketing, and aircraft lease rentals. Output is being measured in terms of either total assets of the airline or in terms of total revenue of the airline.

X_j includes control factors that affect the costs of management and administration of an airline. In Equation 1, ASSETS represent the total assets under management at a company. When we measure cost efficiency with respect to total assets, we use total revenues of the company as a control variable. Similarly, when we measure cost efficiency with respect to total revenue, we use total assets of the company as a control variable.

Cost Elasticity

The most common measure of operating efficiency in economies of scale studies is the elasticity of cost with respect to the output. When the rate of increase in output exceeds the rate of increase in cost in an industry, economies of scale characterize that industry. For the industry, cost elasticity with respect to assets can be used to evaluate the existence and extent of economies of scale. It is measured by percentage change in cost associated with a percentage change in output. We calculate this elasticity by taking the first derivative of the translog cost function (Equation 1) with respect to assets. The result is Equation 2.

$$\frac{\partial(\ln COST)}{\partial(\ln OUTPUT)} = \beta_1 + \beta_2(\ln OUTPUT) \qquad (2)$$

Where COST can represent
- o Total operating expenses; or
- o salary & benefits expenses, or
- o aircraft fuel expenses, or
- o station operations expenses, or
- o maintenance & repairs expenses, or

And output represents
- o Total assets; or
- o Total revenue

If cost elasticity is less than one, airline's expenses increase less than proportionately with changes in its assets. This implies that economies of scale exist. If the elasticity is greater than one, we can infer that diseconomies of scale exist.

To investigate the existence of economies of scale, we estimate the scale economy measure for each observation and then average across observations to derive the group scale economy measure. The cost elasticity is found for each observation (airline). Then an average across observations is computed to obtain the group average elasticity.

We estimate cost elasticities for the total group of airlines in each annual sample as well as for the combined sample period from 2013 to 2018.

DATA AND METHODOLOGY

The data for the airline industry is obtained from *Mergent Online.* Table 1 provides summary statistics of the data used in this study.

TABLE 1
SUMMARY STATISTICS OF THE DATA USED IN THIS STUDY
FOR THE PERIOD 2013 TO 2018

	Total Assets	Total Passeng Revenue	Wages and Benefits	Aircraft Fuel	Aircraft Maintenance	Total Operating Expense
2013						
Mean	$19,022,519	$15,282,304	$3,428,708	$4,443,097	$850,510	$14,278,572
Std. Dev.	$19,691,119	$15,375,664	$3,307,005	$4,529,451	$685,116	$14,526,932
2014						
Mean	$19,746,316	$ 17,599,152	$3,925,105	$4,868,635	$919,797	$16,159,416
Std. Dev.	$20,206,522	$18,026,929	$3,771,778	$5,069,964	$775,165	$16,755,833
2015						
Mean	$20,842,140	$17,563,024	$4,346,958	$3,002,694	$895,343	$14,581,433
Std. Dev.	$21,007,061	$17,594,108	$4,159,925	$3,022,635	$727,453	$14,802,467
2016						
Mean	$21,658,603	$17,366,402	$4,792,876	$2,476,993	$910,372	$14,745,476
Std. Dev.	$20,658,175	$17,035,412	$4,622,920	$2,397,358	$720,908	$14,621,842
2017						
Mean	$22,571,474	$18,301,075	$5,180,869	$,941,152	$970,389	$16,018,393
Std. Dev.	$21,130,800	$17,579,424	$4,895,755	$2,742,474	$767,644	$15,649,678
2018						
Mean	$25,025,281	$19,144,282	$5,403,903	$3,999,335	$939,337	$17,723,826
Std. Dev.	$24,095,267	$18,413,506	$5,043,936	$3,842,414	$711,182	$17,272,898

Table 1 shows that for the airline industry, on an average:
· total assets have increased by 31.6percent in 2018 relative to 2013

· Total passenger revenue increased by 25.3 percent in 2018 relative to 2013; however, this increase has not been consistent. Total revenue shows an increase in 2014 relative to 2013, but shows a decline in 2015 and 2016 relative to the previous year. In 2017, total passenger revenue again shows an upward tick with an increase over the previous year.

· Wages and benefits have increased by more than 57.6 percent in 2018 relative to 2013.

· Aircraft fuel charges show an increase in 2014 relative to 2013, but show a decline in 2015 and 2016 due to a decline in crude oil prices. In 2017 and 2018, fuel prices now show an upward tick.

· Aircraft maintenance expenses do not show any consistent trend. In 2014, maintenance expenses showed an upward tick, but in 2015, they declined. In 2016 and 2017, maintenance expenses again trend upward, but in 2018, maintenance expenses again show a decline over the previous year. On average, aircraft maintenance expenses show an increase of 10.4 percent in 2018 over 2013.

· Total operating expenses show an increase of 24.1 percent in 2018 relative to 2013.

EMPIRICAL ANALYSIS

Cost Efficiencies With Respect To Total Assets
Table 2 summarizes the regression results of the translog cost function specified in equation 1. Table 2 shows four variations of equation 1. In the first model the natural logarithm of total operating expenses are the dependent variable. In the second, third, and fourth model, we use wages and benefits, aircraft fuel, and aircraft maintenance as the dependent variables, respectively.

Model 1 shows that the natural logarithm of assets has a positive coefficient estimate that is statistically significant. This implies positive cost elasticity in that the level of assets directly affects total operating costs of an airline. Total operating revenue is positively related to the total operating expenses and is statistically significant. Model 2 shows that there is a positive relationship between wages and benefits and size of the airline as measured by total assets, because the coefficient on natural logarithm of assets is positive in model 2 and is statistically significant. Once again, total operating revenue has a positive and statistically significant coefficient.

In model 3, natural logarithm of aircraft fuel costs is the dependent variable. The natural logarithm of assets has a negative coefficient estimate, but it is not statistically significant. This implies the level of assets does not directly affects total aircraft fuel costs for an airline. It is not surprising, because aircraft fuel costs beyond a point are a market determined variable and cannot be influenced by the size of the airline. In model 4, the natural logarithm of assets has a positive coefficient and is statistically significant in explaining the natural logarithm of aircraft maintenance. This implies positive cost elasticity in that the level of assets directly affects the aircraft maintenance costs of an airline.

For all of the four models, the average cost elasticity for the overall sample is positive and below 1.0. A two-tailed t-test shows that the differences are significantly different from 1.0 for total operating expenses, wages and benefits, and aircraft maintenance. For aircraft fuel, the average cost elasticity is 0.98, but it is not statistically significant.

So, airline total operating expenses increase less than proportionately with increases in the total assets. For every one dollar increase in the airline's assets, total operating expenses, on average, increase by $0.58. Cost elasticity for aircraft maintenance is 0.20 and this is the biggest source of cost efficiencies for larger airlines and seems to be the motivating force and argument for mergers in the airline industry. For every one dollar increase in total assets, aircraft maintenance expenses, on average, increase by $0.20. Airlines also reap benefits of economies of scale in wages and benefits

TABLE 2
PANEL DATA REGRESSION RESULTS FOR THE TRANSLOG COST FUNCTION TO MEASURE ECONOMIES OF SCALE WITH RESPECT TO SIZE OF THE AIRLINE AS MEASURED BY TOTAL ASSETS FOR THE PERIOD 2013 TO 2018.

Dependent Variables	Total Operating Expenses	Wages and benefits	Aircraft Fuel	Aircraft maintenance
Number of Banks	9	9	9	9
Dependent Variable: Natural Logarithm of Total Operating Expenses				
Adjusted R-Square	0.99	0.98	0.83	0.90
Ln of Assets	4.17 (4.10*)	6.30 (3.94*)	-2.41 (-0.48)	7.35 (2.85*)
½ (Ln of Assets^2)	-0.22 (-3.24*)	-0.35 (--3.27*)	0.21 (0.62)	-0.44 (-2.54**)
Total Operating Revenue	0.0 (4.45*)	0.0 (2.75*)	0.0 (0.26)	0.0 (2.16**)
Cost Elasticity	0.59 (-10.95*)	0.61 (-6.56*)	0.96 (-1.21)	0.20 (-10.73*)

*statistically significant at 1% level; **statistically significant at 5% level; ***statistically significant at 10% level.

through larger size. Table 2 shows that with every dollar increase in total assets, wages and benefits, on average, increase by $0.61. By combining operations and reducing duplication of efforts, airlines have been able to improve labor efficiency in terms of reduced labor costs.

Although the cost elasticity for aircraft fuel expenses is 0.96, but it is not statistically significant. Aircraft fuel cost is more dictated by market price of crude oil rather than the size of the airline and, as a result, we do not see any economies of scale in aircraft fuel expenses.

Cost Efficiencies With Respect to Total Operating Revenue

Table 3 summarizes the regression results of the translog cost function specified in equation 1 with output being measured in terms of total operating revenue. Table 3 shows four variations of equation 1. In the first model, natural logarithm of total operating expenses are the dependent variable. In the second, third, and fourth model, we use wages and benefits, aircraft fuel, and aircraft maintenance as the dependent variables, respectively.

Model 1 shows that the natural logarithm of total operating revenue has positive coefficient estimate that is statistically significant. This implies that the level of total operating revenue directly affects total operating costs of an airline. The coefficient on total assets are positively related to the total operating expenses and is statistically significant. Model 2 shows that there is a positive relationship between wages and benefits and size of the airline as measured by total operating revenue, because the coefficient on natural logarithm of operating revenue is positive in model 2 and is statistically significant. Once again, total operating revenue has a positive and statistically significant coefficient.

In model 3, natural logarithm of aircraft fuel costs is the dependent variable. The natural logarithm of total operating revenue has negative coefficient estimate and is statistically significant. With higher operating revenue, aircraft fuel cost is lower. Since revenue is a factor of number of tickets multiplied by the price of the ticket, it seems that airlines continue to charge a higher price even when the fuel cost has declined. In model 4, natural logarithm of assets has a positive coefficient and is statistically significant in explaining the natural logarithm of aircraft maintenance.

Average cost elasticity is below 1 and statistically significant for total operating expenses and aircraft maintenance, which points to economies of scale for the airline when size is measured by total operating revenues. For wages and benefits and aircraft fuel, average cost elasticity is more than 1 and statistically significant. With every one dollar increase in total operating revenue, airlines to spend more than a dollar on wages and benefits as well as on aircraft fuel.

Cost Elasticity by Each Year F2013 to 2018

Table 4 summarizes cost elasticity for total operating expenses, wages and benefits, aircraft fuel, and aircraft maintenance for each of the six years from 2013 to 2018.

Table 4 shows that the airlines have been engaged in cost cutting measures since 2013 and have been successful through improved efficiency measures. The average cost elasticity for total operating expenses was 0.63 in 2013. In 2018, the average cost elasticity for total operating expenses for the airline industry was 0.54, which means with an increase in total assets, total operating expenses, on an average, increased more slowly in 2018 relative to 2013.

Similarly, cost elasticity for wages and benefits was 0.68 in 2013 and 0.53 in 2018 and it again shows higher efficiencies in wages and benefits in 2018 relative to 2013. The cost elasticity for wages and salaries continues to show a steady decline since

TABLE 3

PANEL DATA REGRESSION RESULTS FOR THE TRANSLOG COST FUNCTION TO MEASURE ECONOMIES OF SCALE WITH RESPECT TO SIZE OF THE AIRLINE AS MEASURED BY TOTAL OPERATING REVENUES FOR THE PERIOD 2013 TO 2018.

Dependent Variables	Total Operating Expenses	Wages and benefits	Aircraft Fuel	Aircraft maintenance
Number of Banks	9	9	9	9
Dependent Variable: Natural Logarithm of Total Operating Expenses				
Adjusted R-Square	0.998	0.98	0.90	0.89
Ln of Total Operating Revenue	1.47 (3.40*)	2.48 (1.96***)	-7.92 (-2.36**)	5.55 (2.34**)
½ (Ln of Total Operating Revenue^2)	-0.03 (-1.05)	-0.09 (-1.02)	0.60 (2.68**)	-0.32 (-2.00**)
Total Assets	0.00 (0.79	0.0 (0.87)	0.0 (-2.34**)	0.0 (1.40)
Cost Elasticity	0.99 (3.77*)	1.04 (2.37**)	1.70 (6.86*)	0.41 (-10.64*)

*statistically significant at 1% level; **statistically significant at 5% level; ***statistically significant at 10% level.

2013. It seems like airlines continue to find ways to improve labor productivity.

The cost elasticity measure shows the biggest gains in aircraft maintenance costs. Average cost elasticity for aircraft maintenance was 0.29 in 2013 and declined to 0.10 for 2018. Elasticity measures for aircraft maintenance costs also show a steady decline in maintenance expenses relative to size of the airline. In 2018, for every one dollar increase in total assets, aircraft maintenance costs increased by $0.10 only.

Efficiencies with Respect to Total Revenue
Table 5 summarizes the regression results of the translog cost function specified in equation 1b in which size is measured in terms of total revenue. Table 4 shows four variations of equation 1. In the first model, natural logarithm of total operating expenses are the dependent variable. In the second, third, and fourth model, we use wages and benefits, aircraft fuel, and aircraft maintenance as the dependent variables, respectively.

Model 1 in Table 5 shows that increase in total operating revenue results in higher total operating costs, because the coefficient on natural logarithm of total operating revenue is positive and statistically significant. Model 1 in Table 4 shows that the cost elasticity of total operating expenses with respect to total revenue is slightly below 1 at 0.99, but it is statistically significant.

Cost Elasticity for Each Airline For The Period 2013 to 2018
Table 6 summarizes the average cost elasticity for each of the nine airlines with size being measured in terms of total assets for the period 2013 to 2018.

The most efficient airline in terms of keeping the total operating cost down is Delta Airline with an average cost elasticity of 0.23. Even on a year by year basis, Delta's cost elasticity with respect to total operating expenses is 0.23. It is closely followed by American airlines with an average cost elasticity of 0.25. American airlines has shown a consistent decline in the cost elasticity since 2013. United Continental Holdings, Inc. is at number three in attaining cost efficiencies in total operating expenses with average cost elasticity at 0.29. United Continental Holdings, Inc. is also showing consistent improvement in attaining cost efficiencies since

TABLE 4
COST ELASTICITY OF TOTAL OPERATING EXPENSES, WAGES AND SALARIES, AIRCRAFT FUEL, AND AIRCRAFT MAINTENANCE WITH RESPECT TO TOTAL ASSETS BY EACH YEAR FROM 2013 TO 2018

	2013	2014	2015	2016	2017	2018	Panel Data
Total operating Expenses	0.63	0.61	0.60	0.54	0.56	0.54	0.59
	(-3.52*)	(-3.91*)	(-4.02*)	(-4.49*)	(-4.85*)	(-5.10*)	(-10.95*)
Wages and Benefits	0.68	0.65	0.63	0.59	0.57	0.53	00.61
	(-1.94**)	(-2.33**)	(-2.36**)	(-2.73*)	(-3.02*)	(-3.27*)	(-6.56*)
Aircraft Fuel	0.92	0.93	0.94	0.97	0.98	1.00	0.96
	(-0.87)	(-0.72)	(-0.59)	(-0.37)	(-0.21)	(0.02)	(-1.21)
Aircraft Maintenance	0.29	0.25	0.22	0.18	0.14	0.10	0.20
	(-3.53*)	(-3.82*)	(-3.95*)	(-4.41*)	(-4.76*)	(-5.01*)	(-10.73*)

2013. The least efficient airline group is Alligiant Travel Company with an average cost elasticity of 1.04. Alligiant Travel Company showed a cost elasticity below 1.0 in 2017 only. In all other years, they show a cost elasticity above 1, which means that with increase in assets, total operating expenses increased by more than 1.

When we average cost elasticities with respect to wages and benefits for each airline, Delta Airlines is again the most efficient. In fact, Delta is reporting a negative cost elasticity at -0.02, which means with increase in size, Delta's cost in terms of wages and benefits is slightly declining. American airlines has an average cost elasticity of 0.02 for wages and benefits, which means for every one dollar increase in total assets, wages and benefits increase by $0.02 only. United Continental Holdings, Inc. is number three with a cost efficiency score of 0.09. The least efficient airline is Alligiant Travel Company with a cost elasticity of 1.33, followed closely by Hawaiian Holdings, Inc. with a cost elasticity of 1.11.

For aircraft fuel cost, Alligiant Travel Company has the best efficiency score at 0.51 on an average. American airlines, Delta Airline, United Continental Holdings, and Southwest Airline have an average cost elasticity that is above one, which means with increase in size, their aircraft fuel cost has gone up more than proportionately.

Table 5 shows that the main source of cost efficiencies for the airline industry is aircraft maintenance expenses. For each of the five years in the sample, United Continental Holdings, American Airline, Delta Airline, and Southwest Airline have a negative cost elasticity. Negative cost elasticity means that with every increase in the size of the airline fleet, maintenance cost is actually declining. Alligiant Travel Company is the least efficient with a cost elasticity of 1.13.

Table 7 summarizes the average cost elasticity for each of the nine airlines with size being measured in terms of total operating revenue for the period 2013 to 2018.

When size is measured in terms of total operating revenue, American airline, Delta Airline, and United Airline are equally efficient, because cost elasticity of total operating expenses, on average, is 0.94 for each of these three airlines. Alaska Air Group, Inc.,

TABLE 5
COST ELASTICITY OF TOTAL OPERATING EXPENSES, WAGES AND SALARIES, AIRCRAFT FUEL, AND AIRCRAFT MAINTENANCE WITH RESPECT TO TOTAL OPERATING REVENUES BY EACH YEAR FROM 2013 TO 2018

	2013	2014	2015	2016	2017	2018	Panel Data
Total operating Expenses	0.99	0.98	0.98	0.98	0.98	0.98	0.99
	(-1.111)	(-1.30)	(-1.37***)	(-1.45**)	(-1.67***)	(-1.80**)	(3.77*)
Wages and Benefits	1.05	1.04	1.04	1.04	1.02	1.02	1.04
	(1.24)	(0.98)	(0.95)	(0.93)	(0.76)	(0.64)	(2.37**)
Aircraft Fuel	1.62	1.68	1.70	1.70	1.75	1.78	1.70
	(2.32**)	(2.48**)	(2.57*)	(2.68*)	(2.93*)	(3.06*)	(6.86*)
Aircraft Maintenance	0.46	0.43	0.42	0.41	0.39	0.38	0.41
	(-3.79*)	(-3.90*)	(-4.02*)	(-4.17*)	(-4.44*)	(-4.59*)	(-10.64*)

TABLE 6
TRENDS IN COST ELASTICITY FOR EACH AIRLINE WHEN SIZE IS MEASURED IN TERMS OF TOTAL ASSETS FOR THE PERIOD 2013 TO 2018

	Alaska Air Group Inc	American Airlines Group Inc	Delta Air Lines Inc	United Continental Holdings Inc	Jet Blue Airways Corp	Southwest Airlines Co.	Allegiant Travel Company	SkyWest, Inc.	Hawaiian Holdings, Inc.
Cost Elasticity with respect to Total Operating Expenses by each airline									
2013	0.74	0.30	0.26	0.33	0.69	0.48	1.14	0.81	0.96
2014	0.73	0.30	0.25	0.33	0.67	0.47	1.08	0.80	0.92
2015	0.71	0.27	0.25	0.31	0.65	0.45	1.06	0.78	0.93
2016	0.62	0.26	0.26	0.31	0.63	0.43	1.01	0.77	0.91
2017	0.60	0.26	0.25	0.30	0.63	0.42	0.96	0.75	0.90
2018	0.60	0.22	0.23	0.29	0.61	0.41	0.93	0.72	0.87
Average	0.67	0.27	0.25	0.31	0.65	0.44	1.03	0.77	0.91
	(-12.48*)	(-62.73*)	(-146.31*)	(-102.48*)	(-29.02*)	(-50.87*)	(0.92)	(-17.21*)	(-7.42*)
Cost Elasticity with respect to Wages and Benefits by each airline									
2013	0.85	0.15	0.08	0.20	0.77	0.43	1.49	0.96	1.19
2014	0.83	0.14	0.07	0.20	0.74	0.41	1.39	0.95	1.13
2015	0.81	0.11	0.07	0.17	0.71	0.39	1.36	0.92	1.14
2016	0.66	0.09	0.09	0.17	0.68	0.36	1.28	0.89	1.12
2017	0.63	0.09	0.07	0.15	0.67	0.34	1.19	0.87	1.10
2018	0.63	0.03	0.03	0.13	0.64	0.32	1.14	0.82	1.06
Average	0.73	0.10	0.07	0.17	0.70	0.38	1.31	0.90	1.12
	(-6.29*)	(-48.62*)	(-114.22*)	(-77.89*)	(-15.47*)	(--35.85*)	(5.88*)	(-4.75*)	(6.57*)
Cost elasticity with respect to aircraft fuel by each airline									
2013	0.82	1.23	1.27	1.20	0.86	1.06	0.44	0.75	0.61
2014	0.83	1.23	1.28	1.20	0.88	1.07	0.50	0.76	0.65
2015	0.84	1.25	1.27	1.22	0.90	1.08	0.51	0.78	0.64
2016	0.93	1.27	1.27	1.22	0.92	1.10	0.56	0.79	0.66
2017	0.94	1.27	1.27	1.23	0.92	1.12	0.61	0.80	0.67
2018	0.95	1.30	1.30	1.24	0.94	1.13	0.64	0.83	0.69
Average	0.88	1.26	1.28	1.22	0.90	1.10	0.54	0.79	0.65
	(-4.65*)	(23.61*)	(57.49*)	(34.43*)	(-8.48*)	(9.28*)	(-14.67*)	(-17.30*)	(-31.29*)
Cost elasticity with respect to aircraft maintenance by each airline									

TABLE 7
TRENDS IN COST ELASTICITY WITH RESPECT TO SIZE WHEN SIZE IS MEASURED IN TERMS OF TOTAL OPERATING REVENUE FOR EACH AIRLINE FOR THE PERIOD 2013 TO 2018.

	Alaska Air Group Inc	American Airlines Group Inc	Delta Air Lines Inc	United Continental Holdings Inc	Jet Blue Airways Corp	Southwest Airlines Co.	Allegiant Travel Company	SkyWest, Inc.	Hawaiian Holdings, Inc.
Cost Elasticity with respect to Total Operating Expenses by each airline									
2013	1.00	0.95	0.94	0.94	1.00	0.96	1.05	1.01	1.03
2014	1.00	0.93	0.94	0.94	0.99	0.96	1.04	1.01	1.02
2015	1.00	0.94	0.94	0.94	0.99	0.96	1.04	1.01	1.02
2016	0.99	0.94	0.94	0.94	0.99	0.96	1.04	1.01	1.02
2017	0.99	0.93	0.94	0.94	0.99	0.96	1.04	1.01	1.02
2018	0.98	0.93	0.93	0.94	0.99	0.95	1.03	1.01	1.02
Average	0.99	0.94	0.94	0.94	0.99	0.96	1.04	1.01	1.02
	-2.92*	(-26.97*)	(-97.16*)	(-243.72*)	(-5.44*)	(-42.54*)	(17.34*)	(44.26*)	(16.43*)
Cost Elasticity with respect to Wages and Benefits by each airline									
2013	1.09	0.94	0.91	0.91	1.08	0.98	1.24	1.13	1.17
2014	1.09	0.90	0.90	0.91	1.08	0.97	1.23	1.13	1.16
2015	1.08	0.90	0.90	0.91	1.07	0.97	1.22	1.13	1.16
2016	1.08	0.90	0.91	0.91	1.07	0.97	1.21	1.13	1.16
2017	1.05	0.90	0.90	0.91	1.06	0.96	1.20	1.13	1.15
2018	1.05	0.89	0.90	0.91	1.05	0.96	1.19	1.13	1.14
Average	1.07	0.91	0.90	0.91	1.07	0.97		1.13	1.16
	-9.49*	(-13.45*)	(-49.41*)	(-119.75*)	(15.08*)	(-10.98*)	(30.95*)	(151.90*)	(41.08*)
Cost elasticity with respect to aircraft fuel by each airline									
2013	1.35	2.34	2.55	2.56	1.39	2.09	0.37	1.09	0.83
2014	1.38	2.62	2.59	2.57	1.43	2.12	0.45	1.07	0.87
2015	1.40	2.60	2.59	2.55	1.48	2.16	0.51	1.05	0.87
2016	1.44	2.59	2.58	2.53	1.50	2.18	0.56	1.05	0.91
2017	1.61	2.61	2.60	2.55	1.54	2.20	0.61	1.07	0.96
2018	1.64	2.65	2.65	2.55	1.59	2.22	0.68	1.07	1.00
Average	1.47	2.57	2.59	2.55	1.49	2.16	0.53	1.07	0.91
	9.36*	(33.96*)	(121.88*)	(307.89*)	(16.07*)	(58.88*)	(-10.30*)	(11.45*)	(-3.67*)

Cost elasticity with respect to aircraft maintenance by each airline									
2013	0.60	0.08	-0.03	-0.04	0.59	0.21	1.13	0.75	0.88
2014	0.59	-0.07	-0.05	-0.04	0.57	0.19	1.09	0.75	0.86
2015	0.58	-0.06	-0.06	-0.03	0.53	0.17	1.05	0.77	0.86
2016	0.56	-0.05	-0.05	-0.02	0.52	0.16	1.03	0.76	0.84
2017	0.47	-0.07	-0.06	-0.03	0.51	0.15	1.00	0.76	0.81
2018	0.45	-0.09	-0.09	-0.03	0.48	0.14	0.97	0.75	0.80
Average	0.54	-0.04	0.06	-0.03	0.53	0.17	1.04	0.76	0.84
	-17.11*	(-42.38*)	(-151.63*)	(-385.15*)	(-28.86*)	(-78.55*)	(1.81**)	(-78.53*)	(-11.70*)

Jet Blue Airways Corporation, and Southwest Airlines Company have a cost elasticity of total operating expenses with respect to total operating revenue equal to 0.99, 0.99, and 0.96, respectively, which means that their operating cost is rising less than proportionately to increase in revenue. On the other hand, Allegiant Travel Company, SkyWest, Inc., and Hawaiian Holdings, Inc. have an average cost elasticity of 1.04, 1.01, and 102, respectively. For every one dollar increase in total revenue, their operating cost increased by more than a dollar.

SUMMARY AND CONCLUSIONS

Over the last decade, the U.S. airlines industry has transformed itself through mergers, restructurings, bankruptcies, and dissolutions. Also during this time, airline executives have changed their focus from a "market share at all costs" mentality to one based on obtaining and preserving profitability, along with a focus on improving return on invested capital by reducing the operating costs. This study evaluated cost efficiencies of U.S. airlines for the period 2013 to 2018. We found that the airline industry is experiencing cost efficiencies with every increase in the size of the airline, but cost efficiencies are not evenly distributed. We also found that the main source of cost efficiency appears to be aircraft maintenance expenses. This study was completed before the current tsunami unleased by coronavirus. The airline industry is perhaps the hardest hit industry due to coronavirus. It will be interesting to analyze the impact of this event on the industry in years to come and how the industry restructures to get out of the economic downturn that started with this virus.

Coronavirus (COVID-19) has impacted the airline industry in the worst possible manner with, at one point, practically all flights grounded around the globe. In the pre-pandemic era, the airline industry's profits rose with an increase in their load factor from 75% in 2005 to close to 85% in recent years. In the post-pandemic world, the airline industry will have to rethink its strategy by reinventing its business model. The business strategy of focusing on asset utilization, to cost leadership, to economies of scale will need to be reevaluated and rebalanced with market needs in the post pandemic world.

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