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OPERATIONAL EFFICIENCY IN THE U.S. AIRLINE INDUSTRY: AN EMPIRICAL INVESTIGATION OF POST-DEREGULATION ERA

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Abstract: *The purpose of this paper is threefold: (1) to examine the operational efficiency of U.S. airlines after the deregulation of 1978; (2) to investigate whether operational efficiency is associated with changes in financial position of firms in the industry and (3) to study if there is an observable pattern in the efficiency measures for large and small airlines. The results indicate that small U.S. airlines record higher scores than large U.S. airlines in four out of five efficiency measures examined. The exception is in the category of allocative efficiency where large airlines exhibit more optimal input mix of resources that their smaller counterparts. This superior mix of resources is consistent with cost minimization. In addition, the analysis shows that higher overall efficiency measures are associated with higher net profit margins of the airlines in the sample, while higher allocative efficiency seems to correlate with higher return on equity.*

Key words: U.S. airlines, efficiency, performance
JEL: L60, C14

I. INTRODUCTION

The airline industry is a service industry that is very capital and labour-intensive. Through the years, U.S. airlines have earned net profit margins that are consistently below the average for U.S. industry as a whole (ATA, 2010). A competitive industry would be expected to earn its cost of capital, but most airlines have been unable to do so (Pearce, 2006). According to the U.S. Department of Transportation Form 41 Financial

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Data, from 1977 through the third quarter of 2007 U.S. airlines combined generated $55 billion in operating profits, but experienced net combined losses of more than $13 billion. Also, the average operating and net margins of U.S. airlines for the same periods were 1.97% and - 0.17% respectively. The geometric mean of accounting Return on Equity (ROE) calculated as income before tax over equity over the same period was only 0.21%. Clearly, the U.S. airline industry has failed its long term investors as it has not been capable of sustaining profitability. As presented on Figure 16 and Figure 17, U.S. airline industry operating profits and margins have been very volatile.

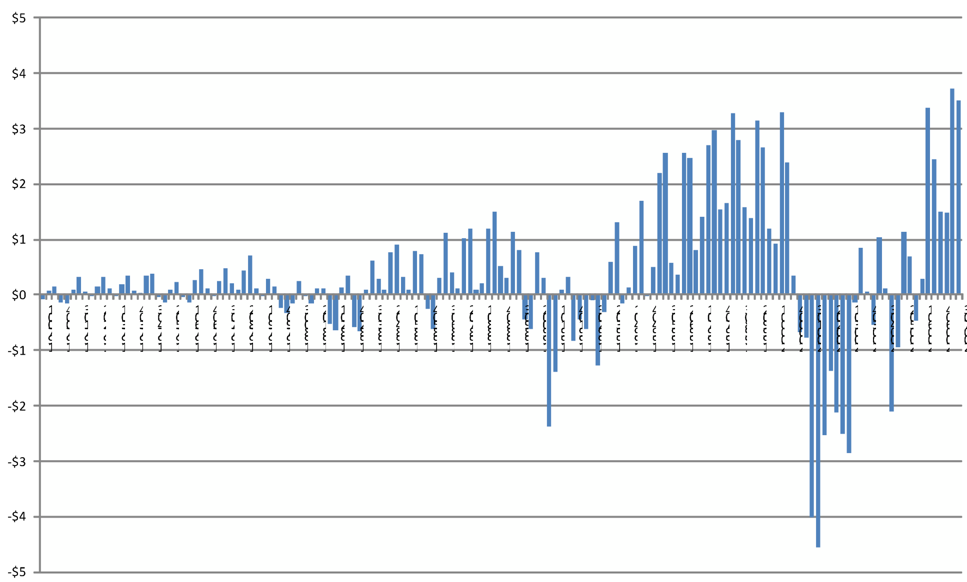

Figure 16 *U.S. Airline Industry Quarterly Operating Profit (Loss) in $ Billion from Q1 1977 to Q3 2007*

Source: Form 41 Financial Data of the U.S. Department of Transportation

During the late 1970's and early 1980's the U.S. airline industry experienced dramatic changes. The 1978 Airline Deregulation Act stimulated competition in the previously highly regulated airline industry. The legislation initially allowed fare reductions of up to 70% without the approval of the Civil Aeronautical Board (CAB), and permitted automatic entry of new airlines into existing routes. The Act phased out the regulatory authority of the CAB and eliminated the agency altogether in 1984. A new regulatory and competitive environment should enhance the ability of the airlines to adjust to price changes in their input and output markets and reduce losses from incorrect service level and price combinations. In regulated industries, such as airlines, public interest considerations dictate that structural changes should be managed to protect the viability of the airline transportation system while encouraging competition and promoting productive efficiency. With U.S. airlines unable to generate sustainable profits since deregulation, their production efficiency has to be improved to enable them to survive in an increasingly competitive and global environment.

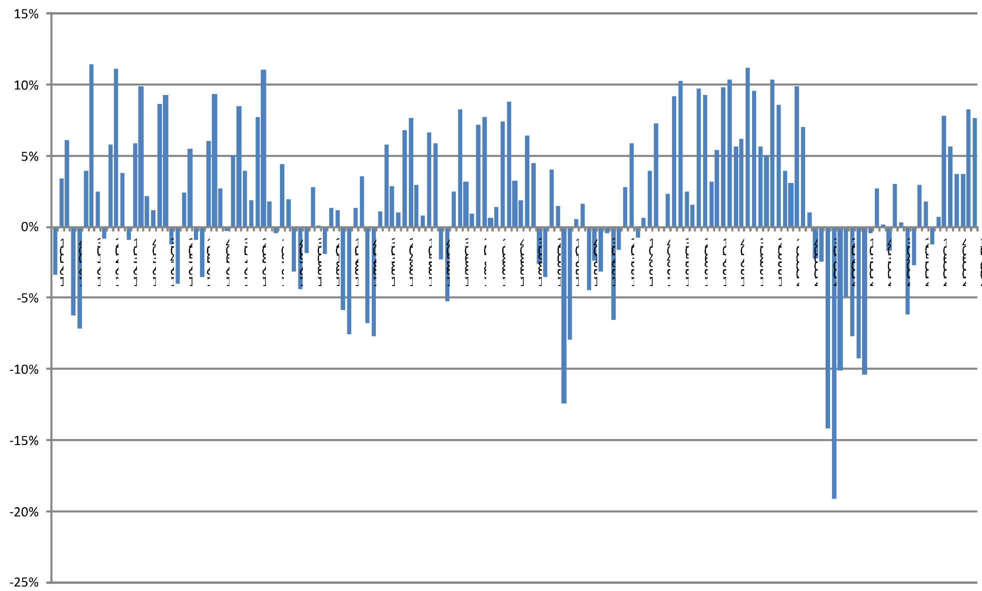

Figure 17 *U.S. Airline Industry Quarterly Operating Margin from Q1 1977 to Q3 2007*

Source: Form 41 Financial Data of the U.S. Department of Transportation

A number of studies investigate various aspects of productivity in the airline industry (Atkinson and Cornwell, 1994; Sickles, Good, and Getachew, 2002; Kumbhakar, 1992; etc.). Sickles, Good, and Johnson (1986) analyze departures from efficient resource allocation in the U.S. airline industry during the period 1970-1981 using a model of allocative distortions. Their results support the fact that deregulation reduced both the total cost and relative level of allocative distortions. Adrangi, Chow, and Raffiee (1996) study passenger output and labour productivity of the U.S. airlines using a generalized Fuss normalized quadratic profit function. Their findings provide evidence on the differing abilities of the airlines to enhance their passenger output and alter employment numbers after deregulation and suggest that the effects of deregulation on the airline industry are complex. Alam and Sickles (2000) employ time series analysis of airline efficiency measures to examine an empirical relationship between technical efficiency and market forces and find that competitive pressure enhances efficiency and they also report less dispersion in firm efficiency over time. The above studies are not directly comparable due to differences in model specification, time periods, and productivity measures.

A number of studies (e.g., Barth, Beaver, and Landsman, 1998; Lev, 1989; Lev and Thiagarajan, 1993, etc.) report a weak relation between stock prices and accounting earnings of firms and argue that firm-specific characteristics and various financial ratios should be added to a model in order to strengthen the relation. Cebenoyan (2003) utilizes an efficiency measure estimated using stochastic frontier methodology in addition to earnings, accounting ratios, and firm-specific variables and finds that the efficiency measure explains some of the previously reported differences in the relevance of earnings to stock returns.

In this paper we employ non-parametric approach to estimate several efficiency indices to assess operational performance in the US commercial airline industry. We also investigate whether efficiency measures are correlated with financial characteristics or profitability ratios.

The rest of the paper is organized as follows: section II explains the data and methodology, section III presents and discusses the empirical results, and section IV concludes the paper.

II. DATA AND METHODOLOGY

A. Data

To estimate inputs and outputs for efficiency measures and financial ratios for U.S. airlines, we use Form 41 Financial Data of the U.S. Department of Transportation. Form 41 contains financial information on large U.S. certified air carriers including balance sheets, income statements, cash flows, aircraft inventory, operating expenses, revenue passenger miles (RPM), yield, available seat miles (ASM), costs per ASM, etc. The sample consists of 151 quarterly observations for 16 U.S. airlines from the first quarter of 1977 to the third quarter of 2007. Several individual airline observations contains fewer quarters due to the fact that those airlines were not in existence over the whole sample period. To compute efficiency indices, we use 5 inputs and 3 outputs. The inputs are denoted by x, the output by y and they are defined as follows: x1 measures number of aircraft seats available to carry passengers, x2 indicates number of employees, x3 measures fuel in gallons per period, x4 represents the total value of flight assets in dollars, x5 stands for the total value of non-flight assets, y1 indicates total number of revenue passenger miles per period, y2 represents total passenger revenues, y3 measures total mail and freight revenues, and, finally, total cost of operation is used as observed total cost incurred.

B. Methodology

To examine the efficiency of US airline companies, we use non-parametric order to estimate several efficiency indices for the companies. In this approach a set of "best practice" frontiers is constructed by solving several linear programming models and employing observed data on inputs utilized and outputs produced by airlines included in the sample. Specifically, we first compute each company's cost efficiency by solving the following linear programming model to estimate the potential minimum total operating cost of each company:

$$\begin{aligned} C_i^* &= \min \quad p \times x \\ y_i &\leq zY \\ x_i &\geq zX \\ z &\geq 0 \end{aligned} \qquad \text{(LP1)}$$

Where

C_i^* is the potential minimum total cost of production of company i and p is a vector of input prices.

y_i is a vector of outputs produced by company *i* of dimension (1, m)

x_i is a vector of inputs utilized by company *i* of dimension (1, n)

Y is a matrix of observed outputs of all companies in the sample of dimension (m, N)

X is a matrix of observed inputs of all companies in the sample of dimension (n, N)

Z is an intensity vector.

N is number of firms in the sample.

Having calculated the potential minimum total cost of production of company i (C_i^*), we then, compute the ratio of C_i^* to the observed total cost, denoted by C_i . This ratio is called overall efficiency (OE) of firm i.

More formally, OE for company i is a ratio defined as follows:

$$OE_i = \frac{C_i}{C_i^*}$$

The second efficiency index that we compute is the overall technical efficiency (OTE). This index measures the technical efficiency of the company under assumption of constant returns to scale (CRS). The OTE can be further decomposed in into two other efficiency indices in order to identify the sources of OTC. One index assesses the company's efficiency relative to a technology that exhibits both CRS and well as variable returns to scale. This index is called pure technical efficiency (PTE) while the other efficiency index is called scale efficiency (SE) which provides information to indicate whether the company operates at optional or at sub-optimal scale. Specifically, we can write:

$$OTE_i = PTE_i \times SE_i$$
$$where$$
$$SE_i = \frac{OTE_i}{PTE_i}$$

To estimate OTE of the company i we solve the following linear programming problem (LP) for each company in the sample:

$$\begin{aligned} &\min\ \lambda_i \\ &y_i \leq zY \\ &\lambda_i x_i \geq zX \\ &z \geq 0 \\ &i = 1,......., N \end{aligned} \qquad \text{(LP1)}$$

Where all variables are as defined earlier, λ_i is the OTE calculated for firm *i* relative to a technology that is characterized by CRS, and *i* = 1….N.

The above LP is solved for each company in the sample to obtain the OTE for such company. To calculate PTE (denoted by θ_i for firm *i*) - we resolve LP1 for each company in the sample by adding $\sum_{i=1}^{N} z_i = 1$ as an additional constraint. Having obtained the OTE and PTE for company *i*, the scale efficiency index (SE) for the company i is calculated as:

$$SE_i = \frac{OTE_i}{PTE_i} = \frac{\lambda_i}{\theta_i}$$

The company is said to be scale efficient if SEi = 1 and if 0 < SE <1 for a given company, that company is said to be scale inefficient or operating at sub-optimal scale.

Finally, we compute allocative efficiency (AE) which measures the deviation of the operation from the optimal input mix of resources that is consistent with cost minimization. AE is determined as:

$$AE_i = \frac{OE_i}{OTE_i}$$

We summarize the efficiency indices defined above as follow:

$$OE_i = OTE_i \times AE_i$$
$$then$$
$$OTE_i = PTE_i \times SE_i$$
$$and\ then$$
$$OE_i = PTE_i \times SE_i \times AE_i$$

We obtain the efficiency indices above by pooling data for all companies for all years. Specifically, we assume that the companies have access to the same technology and are facing common frontiers.

III. EMPIRICAL RESULTS

The summary statistics for the efficiency indices computed relative to the corresponding frontiers for combined years 1977 to 2007 are presented in Table 7. We partition the firms into two sub-samples; one sub-sample is classified as major (large) airlines and includes American Airlines, Continental Airlines, Delta, Northwest Airline, United Airlines, US Airways, and Southwest Airlines. The other sub-sample is classified as non-major (small) airlines and includes Alaska Airlines, Comair, Atlantic Southeast, Frontier Airlines, Hawaiian, Express jet Airlines, American Eagle, and Aloha. We make the distinction between major and non-major airlines based on the total annual 2006 operating revenues (last whole year in the sample). The median figure of annual operating revenues for the airlines in the sample is $2.7 billion. All seven major airlines exceed the median in terms of their annual operating revenues with the largest figure of $22.5 billion for American Airlines and the smallest figure of $8 billion for US Airways. Out of nine non-major airlines in the sample Aloha and Alaska Airlines had the lowest and the highest 2006 operating revenues of $395 million and $2.7 billion respectively. Panel A of this Table displays the efficiency indices for major (large) airlines in the sample and Panel B shows efficiency indices for non-major companies. Selected revenue and profitability statistics are presented in Table 8.

Table 7 *Summary Statistics of the Efficiency Measures Relative to the Pooled Sample Frontier of Selected Airlines, 1977-2007*

Panel A. Major Airlines

	OE	*AE*	*OTE*	*PTE*	*SE*
American Airlines					
Mean	0.470	0.757	0.620	0.755	0.821
St. Dev	0.098	0.980	0.099	0.088	1.131
Min	0.256	0.594	0.431	0.591	0.729
Max	0.703	0.789	0.891	1.000	0.891
Delta Airlines					
Mean	0.468	0.765	0.612	0.712	0.859
St. Dev	0.120	0.912	0.132	0.106	1.244
Min	0.248	0.589	0.421	0.526	0.800
Max	1.000	1.000	1.000	1.000	1.000
Northwest Airlines					
Mean	0.473	0.741	0.638	0.879	0.726
St. Dev	0.113	0.885	0.128	0.117	1.090
Min	0.249	0.943	0.264	0.299	0.883

	OE	*AE*	*OTE*	*PTE*	*SE*
Max	0.910	0.910	1.000	1.000	1.000
Continental Airlines					
Mean	0.453	0.696	0.651	0.790	0.824
St. Dev	0.116	0.900	0.129	0.143	0.898
Min	0.260	0.639	0.407	0.462	0.881
Max	0.116	0.900	0.129	0.143	0.898
US Airways					
Mean	0.465	0.770	0.603	0.651	0.926
St. Dev	0.118	0.894	0.132	0.142	0.927
Min	0.207	0.600	0.345	0.351	0.983
Max	0.875	0.875	1.000	1.000	1.000
Southwest Airlines					
Mean	0.451	0.717	0.629	0.653	0.963
St. Dev	0.097	1.044	0.093	0.110	0.851
Min	0.285	0.620	0.460	0.466	0.987
Max	0.883	0.883	1.000	1.000	1.000
United Airlines					
Mean	0.493	0.756	0.653	0.807	0.809
St. Dev	0.110	0.829	0.133	0.130	1.029
Min	0.265	0.694	0.382	0.468	0.816
Max	0.731	0.731	1.000	1.000	1.000
All Major Airlines					
Mean	**0.468**	**0.743**	**0.630**	**0.750**	**0.847**

Panel B. Non-Major Airlines

	OE	*AE*	*OTE*	*PTE*	*SE*
Aloha					
Mean	0.504	0.827	0.610	0.690	0.883
St. Dev	0.139	0.879	0.159	0.113	1.406
Min	0.262	0.726	0.361	0.521	0.693
Max	0.886	0.886	1.000	1.000	1.000
Alaska Airlines					
Mean	0.462	0.721	0.641	0.675	0.949
St. Dev	0.116	0.745	0.156	0.141	1.109
Min	0.238	0.672	0.354	0.423	0.837
Max	0.753	0.753	1.000	1.000	1.000
America West Airlines					
Mean	0.508	0.712	0.714	0.768	0.930
St. Dev	0.103	0.823	0.126	0.144	0.872
Min	0.314	0.658	0.477	0.516	0.924
Max	1.000	1.000	1.000	1.000	1.000
Atlantic South-East					
Mean	0.573	0.710	0.807	0.825	0.978
St. Dev	0.094	1.337	0.071	0.074	0.956
Min	0.452	0.694	0.651	0.655	0.994

	OE	*AE*	*OTE*	*PTE*	*SE*
Max	1.000	1.000	1.000	1.000	1.000
Hawaiian Airlines					
Mean	0.480	0.662	0.725	0.770	0.941
St. Dev	0.145	0.695	0.209	0.165	1.266
Min	0.212	0.642	0.330	0.438	0.753
Max	0.817	0.817	1.000	1.000	1.000
American Eagle					
Mean	0.619	0.849	0.729	0.759	0.961
St. Dev	0.113	0.924	0.123	0.124	0.989
Min	0.451	0.859	0.525	0.540	0.972
Max	1.000	1.000	1.000	1.000	1.000
Comair					
Mean	0.410	0.610	0.671	0.675	0.995
St. Dev	0.051	0.873	0.059	0.060	0.974
Min	0.319	0.560	0.570	0.571	0.998
Max	0.445	0.624	0.713	0.717	0.994
Expressjet Airlines					
Mean	0.576	0.616	0.935	0.944	0.991
St. Dev	0.038	0.591	0.064	0.059	1.093
Min	0.498	0.603	0.826	0.834	0.990
Max	0.661	0.661	1.000	1.000	1.000
Frontier					
Mean	0.524	0.584	0.896	0.927	0.967
St. Dev	0.133	1.216	0.109	0.078	1.407
Min	0.185	0.439	0.421	0.726	0.580
Max	1.000	1.000	1.000	1.000	1.000
All Non-Major Airlines					
Mean	**0.517**	**0.699**	**0.748**	**0.781**	**0.955**

Panel C. Aggregate for All Airlines

	OE	*AE*	*OTE*	*PTE*	*SE*
All Airlines					
Mean	0.483	0.730	0.662	0.752	0.880
St. Dev	0.121	0.791	0.153	0.147	1.041
Min	0.185	0.701	0.264	0.299	0.883
Max	1.000	1.000	1.000	1.000	1.000

Table 8 *Selected Revenue and Profitability Statistics*

	Average Operating Income ($ Bln)	*Average Net Income ($ Bln)*	*Average Operating Margin*	*Average Net Margin*	*Geometric Mean of ROE*	*Operating Revenues 2006 ($ Bln)*
American Airlines	6.36	(1.53)	2.10%	0.37%	-2.45%	22.49
Delta Airlines	4.50	(9.48)	2.11%	-1.13%	0.60%	17.34

	Average Operating Income ($ Bln)	*Average Net Income ($ Bln)*	*Average Operating Margin*	*Average Net Margin*	*Geometric Mean of ROE*	*Operating Revenues 2006 ($ Bln)*
Northwest Airlines	5.11	(0.90)	2.29%	0.68%	1.03%	12.55
Continental Airlines	2.59	(0.50)	0.91%	-1.34%	-5.42%	13.01
US Airways	(0.09)	(2.17)	1.78%	0.15%	0.73%	8.08
Southwest Airlines	9.77	6.25	11.28%	7.04%	4.79%	9.09
United Airlines	(0.26)	(4.41)	-0.82%	-1.36%	0.47%	19.33
Aloha	(0.06)	(0.17)	0.64%	-0.55%	4.02%	0.40
Alaska Airlines	0.77	0.46	2.68%	1.92%	3.26%	2.69
America West Airlines	0.15	(1.06)	-0.60%	-3.73%	-2.58%	3.77
Atlantic South-East	1.36	0.22	16.51%	6.60%	6.60%	1.27
Hawaiian Airlines	(0.25)	(0.32)	-3.41%	-2.26%	-3.05%	0.88
American Eagle	0.94	(0.08)	4.15%	-0.64%	7.32%	1.91
Comair	0.32	(1.82)	5.50%	-30.94%	-15.55%	1.20
Expressjet Airlines	0.95	0.54	9.34%	5.04%	-8.22%	1.67
Frontier	0.10	0.04	-2.14%	-2.63%	-1.80%	1.13
All Airlines	55.06	(13.19)	1.97%	-0.17%	0.21%	116.82

The estimated efficiency indices are somewhat counterintuitive. It seems that four out of five efficiency indices are higher for non-major airlines than for major airlines. Specifically, we observe that the average overall efficiency for major airlines is 46.8% compared to an average of 51.7% for non-major airlines. This suggests that if all major airline companies had been fully overall efficient, they could have potentially saved 53.2% of costs, on average; over sample period while smaller airlines could have potentially saved 48.3% of costs on average. In addition, we note that this relative cost "inefficiency" for large airlines is primarily caused by low overall technical efficiency of 63.0% compared to 74.8% for small airlines. Suboptimal "input-mix" contributes less to this overall inefficiency as major airlines are more allocative efficient at 74.3% compared to 69.9% for small airlines

Comparing the efficiency of major airlines with non-major, the results suggest that only allocative efficiency index (AE) is higher for major than non-major airlines suggesting that major airlines have more optimal input mix of resources consistent with cost minimization than non-major airlines. Furthermore, while one would expect larger airlines to be more scale efficient than their smaller counterparts, surprisingly, scale efficiencies (SE) are better for smaller airlines (at 95.5%) than for larger airlines (at 84.7%). These results suggest that policies that encourage mergers and acquisitions in the airline industry might not be justified on the basis of technical efficiency enhancement but are justified on the allocative efficiency ground. It is suggested that this issue should be re-examined after a number of years following recent mergers and acquisitions in the airline industry.

A closer look at the panels of large and small airlines separately, shows that United Airlines has higher overall efficiency (OE) and above average pure technical efficiency (PTE) than other major airlines. While all of the major airlines are very similar in terms of overall technical efficiency (OTE), Northwest does better with respect to pure technical efficiency (PTE) but worse with respect to scale efficiency (SE). Southwest, on the other hand, is the best among major airlines with respect to SE, but does not do well in terms of PTE. US Airways is very similar to Southwest in terms of PTE, and SE.

The small airline panel of Table 7 also presents some mixed results. While American Eagle seems to be the best among small airlines with respect OE and AE, other airlines are leading with OTE (Frontier), PTE (Expressjet Airlines), and SE (Atlantic South-East).

Since we do not have enough observations for a traditional statistical analysis, we conduct a simple correlation analysis to identify efficiency measures that are associated with profitability and size in the airline industry. The results of correlation analysis are presented in Table 9.

Table 9 *Correlations between Efficiency and Profitability Measures and Airline Size*

	OE	*AE*	*OTE*	*PTE*	*SE*
Operating Margin	0.29	-0.06	0.24	0.00	0.40
Net Margin	0.45	0.33	0.13	0.24	-0.15
ROE	0.42	0.69	-0.19	-0.15	-0.11
Major	-0.47	0.31	-0.59	-0.18	-0.70
Non-Major	0.47	-0.31	0.59	0.18	0.70

As discussed above, positive correlations between AE and large airline group variable confirm that large airlines in the sample have higher allocative efficiency than small airlines. Positive correlations between five other efficiency measures and small airline group variable confirm that small airlines in the sample are more efficient.

The correlations between efficiency measures and profitability ratios are presented in Table 9. As can be seen for this table, while the overall efficiency index has positive correlations with all three profitability ratios, it seems to contribute to Net Profit Margin the most (correlation of 0.45). The allocative efficiency index has a low negative correlation with Operating Profit Margin (-0.06) and positive correlations with Net Profit Margin (0.33) and ROE (0.69). OTE is positively correlated with Operating Profit Margin (0.24) and Net Profit Margin (0.13), and negatively correlated with ROE (-0.19).

Other efficiency measures also produce mixed results with PTE producing zero correlation with Operating Margin, positive (0.24) with Net Margin, and negative (-0.15) with ROE. SE seems to contribute more to Operating Margin (correlation of 0.40). Generally, these findings provide evidence to suggest that there exists some relation between accounting measures of performance and efficiency measures of performance in the airline industry.

IV. CONCLUSIONS

In this paper we examine the operational efficiency of U.S. airlines after deregulation of 1978 and investigate whether the observed efficiency and technological progress are associated with changes in financial position of the firms in the industry. In addition, we also check for any observable pattern in the efficiency measures for large and small U.S. airlines. The results indicate that U.S. large airlines do not demonstrate higher efficiency than small airlines. In fact, small U.S. airlines record higher scores than large U.S. airlines in four out of five efficiency measures examined. The exception is in allocative efficiency where higher measures recorded for large airlines suggest that they have superior optimal input mix of resources than smaller airlines. Superior optimal input mix of resources is consistent with cost minimization. Surprisingly, the analysis does not show any advantage in scale efficiency for large airlines over their smaller counterparts. Nevertheless, correlation analysis of efficiency measures with profitability measures suggests that higher overall efficiency measures are associated with higher net profit margins for the airlines in the sample, while higher allocative efficiency correlates with higher return on equity for the airlines.

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