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Identifying airline cost economies: An econometric analysis of the factors affecting aircraft operating costs

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A R T I C L E I N F O

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A B S T R A C T

This paper provides the results of an econometric analysis of the influences of airline characteristics on the average operating costs per aircraft movement. The analysis combines a comprehensive selection of airline-output variables, airline-fleet variables, and airline-market variables. The results confirm the existence of economies of density, economies of load factor, economies of aircraft utilisation and economies of aircraft size. The paper does not provide evidence of economies of scale, economies of stage length or economies of fleet commonality. Furthermore, airlines that additionally operate full freighters, airlines that are members of a worldwide alliance and airlines that operate a multi-hub system face higher average operating costs per aircraft movement. Surprisingly, the regression results demonstrate that airlines that use newer aircraft have higher average operating costs per aircraft movement, suggesting that ownership costs (depreciation and leasing costs) of new aircraft outweigh the increasing maintenance costs of old aircraft. Finally, the results show that airlines that have a dominant position at their hubs or bases have higher operating costs per aircraft movement, implying that the absence of serious competitive pressure enables airlines to charge higher ticket prices and, with that, leads to a limited focus on cost savings.

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1. Introduction

Today, the margins of most airlines are under constant pressure. Even in economic booms, many airlines scarcely make a profit. This mainly stems from the substantial increase in competition in the airline industry over the last decades. In particular, low-cost carriers have put considerable competitive pressure on the traditional network carriers. Indeed, they have gradually undermined network carriers' ability to practice the price discrimination necessary to recover their total costs (Tretheway, 2004). Morrison (2001) showed that the estimated savings due to actual, adjacent and potential competition from low-cost carrier Southwest Airlines were $12.9 billion, which amounts to 20 per cent of the airline industry's domestic scheduled passenger revenue in the United States in 1998. This implies that the pressure on network carriers' operating costs in the United States increased considerably because of the abovementioned revenue reduction. In Europe, low-cost carriers also put additional pressure on network carriers' operating costs by offering flights at reduced fares. Franke (2004) reported that Ryanair can offer cheap flights because of higher crew productivity, reduced cabin crew, high aircraft utilisation, new-generation aircraft, use of secondary airports, low ground handling charges and a higher average aircraft size. Furthermore, O'Connell (2007) stated that low-cost carriers' ability to offer 80 per cent of the service quality at less than 50 per cent of network carriers' cost jeopardises the future of network carriers in short-haul markets.

It is therefore important to have a clear view of the operating costs per aircraft movement and, perhaps even more relevant, the variables which have the most profound impact on those operating costs. Hence this paper investigates the key drivers of operating costs per aircraft movement using random- and fixed-effects regression techniques based on data from 2007 to 2010. The data used consist of financial and operational information from airlines' annual reports and detailed traffic figures from the Official Airline Guide (OAG). While other papers often focus on just a few factors, the results of this paper provide a comprehensive view of the impact on aircraft operating costs, combining airline-output variables, airline-fleet variables, and airline-market variables. This reduces the likelihood of spurious relationships. Moreover, the focus of this paper is operating costs per aircraft movement, rather than total operating costs as is the case in most existing literature. The

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results enable policy makers, airline managers and researchers to gain additional insight into the most important factors that affect operating costs per aircraft movement and, in turn, into the most profound airline cost economies.

2. Factors influencing airline operating costs

2.1. Existing literature

Early literature on cost economies often focused on the possible existence of economies of scale. Based on a meta-analysis, White (1979) concluded that economies of scale in the airline industry were negligible or non-existent at the overall firm level. This finding has been confirmed by several other scholars (see e.g. Braeutigam, 1999; Caves et al., 1984; Gillen and Morrison, 2005). Liu and Lynk (1999) deviated from this general finding by stating that significant economies of network size exist after the deregulation of the United States airline industry. In 1982, Bailey and Friedlaender (1982) mentioned the existence of economies of networking in the aviation industry as a form of economies of scope. In more recent years, different authors have demonstrated the existence of what is currently called economies of density (see e.g. Caves et al., 1984; Brueckner and Spiller, 1994). As a result of the emergence of hub-and-spoke networks, network carriers are able to use planes that are larger than would be the case in point-to-point networks: they concentrate their operation by channelling large passenger flows through their hub airports.

Today, extensive literature exists on the variables affecting airline costs. The majority of this literature focuses on the influence on total airline costs or unit costs. Papers aiming to identify factors that influence airline operating costs per aircraft movement are rather scarce. This section elaborates on the factors mentioned in the existing literature.

Most papers on the impact on airline costs have included variables measuring an airline's output in terms of traffic. Proxies often used to measure output are revenue passenger miles (RPM), number of seats offered, number of departing flights and number of carried passengers. All papers focussing on total cost function have found, not surprisingly, positive effects of airline output on airline total costs (Caves et al., 1984; Gillen et al., 1990; Windle, 1991; Banker and Johnston, 1993; Hansen et al., 2001). On the other hand, output has a negative effect on the average operating costs of an airline, as Baltagi et al. (1995) concluded. This implies that an increase in traffic density results in a decrease in unit costs and thus in a decrease in operating costs per aircraft movement, which signals the presence of economies of density. Additionally, studies have often concluded that the more points an airline serves, the higher the total costs of the airline (Caves et al., 1984; Windle, 1991; Hansen et al., 2001), which proves that a diverse network is more costly. The number of points an airline serves correlates positively with average costs (Baltagi et al., 1995), but also with the airline's operating margin (Gitto and Minervini, 2007).

The average stage length of an airline is often acknowledged as the most important cost driver (Hazledine, 2010) because with an increase in the average stage length, important variable costs concerning fuel, staff and maintenance increase. However, many authors have demonstrated that, keeping other (output) variables constant, the average stage length of an airline has a negative effect on the total costs of the airline (Caves et al., 1984; Gillen et al., 1990; Banker and Johnston, 1993), which is obvious evidence of the existence of economies of stage length. Moreover, other studies have pointed out that an increase in the average stage length correlates negatively with the average or unit costs and with the average air fare (Baltagi et al., 1995; Bitzan and Chi, 2006; Tsoukalas et al., 2008). Ryerson and Hanson (2013) found a slightly less than proportional positive effect on an airline's direct operating costs per departure. Still, results are not unanimous: Chua et al. (2005) found no significant effect of stage length on total costs, while Brüggen and Klose (2010) found no evidence of a relationship between route length and an airline's operating performance. Furthermore, Mantin and Wang (2012) reported a negative relationship between stage length and operating profit margin.

The results of the analysis of the impact of the average load factor on airline costs are rather straightforward. Most studies have found a negative relationship between load factor and total airline costs (Caves et al., 1984; Windle, 1991; Hansen et al., 2001; Chua et al., 2005), implying that a higher load factor leads to lower total costs, which is evidence of the existence of substantial economies of load factor. In accordance with this, Bitzan and Chi (2006) found a negative effect of load factor on average air fares, Baltagi et al. (1995) found a negative effect on average airline costs and Antoniou (1992), Tsikriktsis (2007) and Mantin and Wang (2012) concluded that an airline's load factor has a positive impact on its operating margin. Only Gitto and Minervini (2007) found a deviating result: no effect of load factor on operating margin.

Previous literature has pointed to the influence of different fleet characteristics on an airline's cost performance. First, several scholars concluded that significant cost economies of aircraft size exist (Nicol, 1978; Banker and Johnston, 1993; Wei and Hansen, 2003; Ryerson and Hansen, 2013), implying that larger aircraft are more cost efficient. This is supported by Bitzan and Chi (2006), who found that aircraft size correlates negatively with average air fares. Second, several authors have studied the impact of aircraft age on operating performance and airline costs. While Antoniou (1992) found a negative relationship between aircraft age and operating margin and Ryerson and Hansen (2013) found that increasing aircraft age leads to higher direct operating costs per departure, Banker and Johnston (1993) found no evidence of any relationship. The notion that the normally higher maintenance costs of older aircraft are compensated by lower ownership costs (depreciation or leasing costs) (Swan and Adler, 2006; Berrittella et al., 2009) supports the conclusion that there is no obvious effect of aircraft age on airline costs. Hazel et al. (2012) even concluded that aircraft older than 15 years have lower maintenance

Table 1
Descriptive statistics.

Variable	Mean	Std deviation	Min value	Max value
Operating costs per aircraft movement (in USD)	24,100	20,476	3620	111,390
North America (share)	0.2227	0.4171	0.0000	1.0000
Asia (share)	0.2133	0.4106	0.0000	1.0000
Other regions (share)	0.2180	0.4139	0.0000	1.0000
Europe (share)	0.3460	0.4768	0.0000	1.0000
Average stage length (in km)	1595	880	295	4640
Number of operations	296,185	373,920	8819	2,134,024
Number of points served	95	73	10	387
Average load factor	0.7518	0.0672	0.5970	0.8750
Average aircraft size	164	46	42	334
Aircraft utilization (×1000 km)	2610	877	712	5161
Fleet commonality	0.4762	0.2643	0.1332	1.0000
Share of turboprop	0.0962	0.1916	0.0000	1.0000
Share of full freighter	0.0156	0.0354	0.0000	0.1722
Average aircraft age	8.5	3.6	2.0	21.4
Oil price (in USD per barrel)	79	12	57	107
Staff costs/employee (×1000 USD)	64.5	30.7	5.4	146.8
Number of hubs	1.8	1.6	0.0	7.0
Route dominance	0.5327	0.1882	0.1304	1.0000
Hub dominance	0.4126	0.2047	0.0566	0.9336
Alliance membership	0.4550	0.4992	0.0000	1.0000
Private ownership	0.7109	0.4544	0.0000	1.0000

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