Chinese airline efficiency under CO₂ emissions and flight delays: A stochastic network DEA model

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A R T I C L E   I N F O

Article history:
Received 18 April 2017
Received in revised form 14 August 2017
Accepted 11 September 2017
Available online 23 September 2017

JEL classification:
R41
R43
Q53
Q41
Q48
C61

Keywords:
Chinese airlines
Stochastic network DEA
Undesirable outputs
CO₂ emissions
Flight delays

A B S T R A C T

This article focuses on the efficiency assessment of 13 major Chinese airlines from 2006 to 2014, applying a stochastic network DEA (SNDDEA) to account for randomness in undesirable outputs such as flight delays and CO₂ emissions. Two stages are considered: flight and network efficiency. Efficiency estimates are computed using multivariate copulas to control for time (trend) and individual (DMU) effects. A robust regression approach is subsequently developed to address the impact of contextual variables on efficiency levels. Results suggest that more progress has been made over the course of the years in terms of controlling flight delays that in terms of reducing CO₂ emissions. These results call for specific policies that can target the latter issue more properly: authorities should pay a closer look on airlines listed in the stock market and that operate international flights to apprehend best practices and design regulatory marks to the sector. This paper also lends a distinctive contribution to the literature by modeling the first time the trade-off between flight delays and CO₂ emissions in airline efficiency problems.

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1. Introduction

Accelerated economic growth over the past decades due to a globalized flow of people and goods has substantially increased airlines' energy costs and CO₂ emissions. According to statistical data of the International Air Transport Association (IATA, 2015), in 2012, the total energy cost for airlines was >160 billion dollars, measured on a worldwide base. Besides, the CO₂ emission volume was >0.767 billion tons at that time. In fact, the aviation industry is one of the few sectors where energy consumption has increased at a rate of >5% over the past 10 years. This research focuses on the technical efficiency of Chinese airlines by using a novel SNDDEA model for network and flight efficiency, built upon multivariate copulas and capable of handling undesirable outputs such as CO₂ emissions and flight delays. It is important to mention now to readers the distinctive nature of the word “network” that appears in this research. It appears both as the descriptor of the modeling approach adopted – Network DEA, for a productive process that encompasses several sequential stages – and as the name of one of the productive stages modeled within the ambit of the airlines’ operation – network efficiency, for an airline that efficiently converts physical and human resources into landings and take-offs with minimal delays.

Previous research on airlines have adopted several methods such as (i) factor productivity approach (Bauer, 1990; Oum and Yu, 1995; Barbot et al., 2008); (ii) Stochastic Frontier Analysis or SFA models (Good et al., 1993; Baltagi et al., 1995; Tsionas et al., 2017); (iii) Turnquist total factor productivity index (Coelli et al., 2003; Barbot et al., 2008); (iv) Data Envelopment Analysis or DEA models (Markert and Hersch, 2011; Barros et al., 2013; Barros and Pepycho, 2009; Barros and Couto, 2013; Cao et al., 2015; Li et al., 2015; Wanke and Barros, 2016; Cui and Li, 2017a, 2017b; Zhang et al., 2017); and (v) multi-criteria decision-making models such as TOPSIS (Barros and Wanke, 2015; Wanke et al., 2015). On the other hand, it is worth noting that, within the airline efficiency ambit, DEA-based studies are the most numerous when compared to the SFA-based methods and other minor approaches used (Wanke et al., 2015; Barros and Wanke, 2015; Wanke and Barros, 2016; Li and Cui, 2017; Cui and Li, 2017a, 2017b). This not only replicates a pattern that is found in papers focused on efficiency analysis in other industries such as ports and banking (e.g. Wanke et al., 2016a, 2016b),