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Have Asian airlines caught up with European Airlines? A by-production efficiency analysis

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ABSTRACT

This paper extends previous approaches to meta-efficiency measures by incorporating meta-frontiers using good-output, bad-output and by-production efficiencies to compare European and Asian airlines. We also examine whether the heterogeneity in environmental regulatory standards between these regions has emboldened Asian airlines to be less eco-friendly and/or more market-share seeking. We find that the environmental performance of European airlines improved continuously between 2007 and 2013, unlike their competitors in Asia. We argue that this improvement in the environmental performance of the European airlines could be an outcome of the European Emission Trading Scheme (ETS), which set incentives for European airlines to renew their fleets and optimise their operations. Our technological gap ratio estimates also point to some Asian airlines outperforming all other airlines on technological measures, indicating they operate in a more favourable business environment. Overall, our method contributes to the methodological enhancement of data envelopment analysis (DEA) and allows deeper insights into firm operations in general, and environmental efficiency analysis of European and Asian airlines in particular.

1. Introduction

The aviation industry is a key enabler for the movement of passengers and freight around the world. It is a highly dynamic industry, and over the last 40 years has undergone a number of structural changes requiring significant adjustments to business models to ensure sustainability. The Asian region, led by China and India, has expanded rapidly and become the world's largest aviation market with regard to international departures and international freight in the last decade (IATA, 2014a). In 2012, China was the second-largest domestic passenger air transport market after the US, with a remarkable growth rate of 9.5 per cent (IATA, 2013). Asian airlines also boasted the world's highest margins and largest profits, despite a weakening of the freight segment since 2011 (ICAO, 2013).

While economic growth has been immense, the ecological side of the aviation industry has been mainly ignored. Asian airlines have not faced the threat of serious ETSs, such as the existing ETS in Europe, and some countries (such as China) have even prohibited their airlines from participating in the EU ETS. Regions such as the EU are classified as being in IATA's market evolution Phase 3: the market is large and demand is mature, with privatised companies operating in a deregulated market with minimal government intervention. Airlines in this classification are expected to be highly technically efficient, with competitive air ticket prices that are

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sensitive to changes in costs and low overall profit margins. In addition to high competitiveness and shrinking profit margins, EU airlines have also needed to adapt to increases in operating costs as they have improved their pollution efficiency to comply with ETSs from 2012 (IATA, 2011). IATA reports that the Asian region is in Phase 2 of its evolution, with rapidly increasing demand, a mixture of private and state-owned enterprises, and a highly regulated market with some degree of liberalisation. These factors should lead to decreasing prices and improvement in technical and profit-oriented efficiencies.

We argue that the regulatory differences between Asia and the EU should result in Asian airlines to be less environmentally efficient and more technically efficient (to gain a larger market share and profit) than their European counterparts. If this is true, then the new ETSs or emission reduction regulations in the Asian region could negatively affect the performance of region's carriers (see also Beltrán-Esteve and Picazo-Tadeo, 2015; Doganay et al., 2014). This is a crucial issue, because several Asian countries (such as Japan and Korea) have begun to include airlines in their current ETSs, or are designing new ETSs that include aviation emissions. For instance, Thailand's planned 2017 ETS will put further pressure on Asian airlines to consider their carbon footprints. This study, therefore, compares the technical and pollution-adjusted efficiencies of major Asian airlines on the cusp of ETS regulation with those of European airlines that have met EU ETS requirements since 2012 and are operating in a mature emissions trading market.

Besides the difference in maturity and environmental consciousness, the EU and the Asian market share many similarities (more than other IATA-defined regions, such as North or South America or Africa) which further justifies a meaningful direct comparison. For example, their shares of the international aviation market for both freight and passengers are very similar: in 2013, Asia accounted for 29.3 per cent of the passenger market and 38.8 per cent of the freight market; while Europe accounted for 33.8 per cent and 38.8 per cent respectively (IATA, 2014b). Airlines from both regions face similar costs of capital, at 7.5 to 8.3 per cent in Asia and 7.7 per cent in Europe (network/LCC in 2012).[1] The cost of aviation fuel is a major expense for both regions, approximately 33 per cent of the total operating costs in 2013. Further, both regions have similar international passenger load factors: in 2012, passengers represented 78.0 per cent of international loads in Asia and 77.8 per cent in Europe (ICAO, 2013). These similarities allow this study to make meaningful insights into the technical and environmental efficiencies of these airlines relating to the life of older aircraft, and replacement policies or fuel substitutes such as biofuels, which will assist management decisions. Policy makers may also benefit from information to assist them drive ecological and technical improvements in the aviation sector.

An important requirement in comparing heterogeneous decision-making units (here, Asian and European airlines) is the definition of an identical comparison basis. To this aim, Hayami and Ruttan proposed the concept of a meta-production technology to describe the 'full range of alternatives … only partially available to individual producers in a particular country [region, in this study]' (1970, p. 898)). In other words, the meta-production function 'can be regarded as the envelope of commonly conceived neoclassical production functions' (Hayami and Ruttan, 1971, p. 82). It therefore provides tools for meaningful comparisons between different groups. The concept implies that all producers have potential access to the same technology. However, 'specific circumstances such as the qualities and quantities of the natural endowments, the structure of relative prices of the inputs, and the basic economic environment' may lead producers to operate on different local parts of the meta-technology (Lau and Yotopoulos, 1989, p. 242). Simply, producers do not operate on a universal (global) production function, but rather on restricted parts of the production function due to the adoption and diffusion of technology (Gunaratne and Leung, 1996). Recently, the concept of meta-production has been extended to stochastic frontier estimation (Battese and Rao, 2002; Battese et al., 2004). O'Donnell et al. (2008) also propose formulation in the case of a DEA framework. However, because meta-frontier estimation assumes that different existing technologies are combinable, some parts of the virtual global frontier can be infeasible, and not attainable by producers (Breustedt et al., 2007).[2] Therefore, Breustedt et al. (2007) proposes the estimation of a less restrictive and non-concave meta-frontier to overcome this potential drawback of the classic meta-technology estimation. The inclusion of undesirable outputs in production technology models has been the subject of consideration discussion in the DEA literature (Dakpo et al., 2016). Suggested approaches include, for example, treating undesirable outputs as free disposable inputs (Hailu and Veeman, 2001), and considering them as outputs under the weak disposability assumption—WDA (Färe and Grosskopf, 2009). These do, however, have many limitations (Coelli et al., 2007; Murty, 2010; 2012; 2015; Salim et al., 2016, 2017). Murty et al.'s (2012) innovative by-production model, on the other hand, is grounded in solid theoretical reasoning: unlike the earlier approaches (pollution as input or as output under WDA) that use a single (equation) representation of a pollution-generating technology, the by-production approach is based on a multi-equation representation. It assumes one intended technology for the production of the good outputs and one unintended technology for the generation of pollution or undesirable outputs, so that the global technology lies at the intersection of the previous two technologies. This study uses the non-parametric DEA method and proposes an extension of the by-production technology to the estimation of a non-concave meta-frontier in order to rank the airlines in both Asia and Europe.[3] This new extension includes carbon dioxide equivalent (CO_2-e) as an undesirable output in addition to a load measure.

The paper is structured as follows: Section 2 provides a brief review of literature, while Section 3 outlines existing policies and regulations relevant to the study. Subsequently, methodology and data are presented in Section 4. Section 5 discusses the findings of

[1] North America, in contrast, possesses 14.3 per cent of the passenger market and 21 per cent of the freight market. The cost of capital in this region is only 2–4 per cent which is significantly lower and different than those in Europe or Asia.

[2] This case will be discussed later in the paper.

[3] It is worth noting that the potential problem of DEA-based scores of efficiency to rank DMUs is that those scores are obtained with a different set of efficient units and different weights, which might render comparisons among inefficient units meaningless (Kao and Hung, 2005). However, our approach in this paper is not to establish a systematic ranking of airlines but to provide the magnitude of the inefficiencies in the best state of nature (even in the presence of ties). Besides, practically, it might be interesting to consider the projection that requires lesser effort for a firm to reach the production. We would like to thank the anonymous Reviewer for underlying this point.