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The impact of environmental variables on the efficiency of Chinese and other non-Chinese airlines

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A B S T R A C T

This paper explores the impact of an international focus, the proportion of cargo traffic, and the level of salaries on the operational efficiency of Chinese airlines and other non-Chinese airlines. Data envelopment analysis (DEA) is employed to evaluate the operational efficiency and a bootstrapped truncated regression is applied to explore the impact of environmental variables on efficiency. The results show that an international focus has a negative impact, while the level of salaries has a positive impact. Also, we demonstrate that there is an inverted U-shaped relationship between efficiency and the proportion of cargo traffic.

1. Introduction

In previous research, Fethi et al. (2000) argued that an international focus might expose airlines to spatial disparities. Scheraga (2004) also discussed how a higher involvement in international operations might induce lower operational efficiencies due to cabotage and establishment rights. Divergence across geographic regions with regard to competition law, policies in air transport and airport infrastructure constraints could potentially affect the operational performance of international airlines. However in recent years, the world air transport industry has been going through a gradual period of liberalization and so protectionism within the industry has weakened. We therefore hypothesize that the effect of international business on efficiency may have become positive. For example Singapore Airlines, with a strong international focus, is widely regarded as one of the most efficient airlines.

Moreover each year China exports large quantities of products to North American and Europe, as well as having a need for a large domestic cargo transport network. This provides Chinese airlines with an opportunity to develop their air cargo business. So for Chinese airlines offering both passenger and cargo services, this raises the questions as to whether increasing their share of cargo traffic (the cargo business ratio) could improve their operational efficiency. Scheraga (2004) and Hong and Zhang (2010) suggested that raising this ratio would be beneficial. On the one hand, the cargo business requires less input and more flexible transportation conditions than passenger services. Combining passenger services with cargo services may result in higher load factors for the belly compartment of passenger aircraft. On the other hand, cargo flows are much more unbalanced than passenger flows (cargo is usually carried one-way, while passengers usually make a round trip) and thus the cargo business may result in lower load factors and poorer efficiency. So the cargo business can potentially affect load factors in either way but Scheraga (2004) and Hong and Zhang (2010) only discussed the positive impact. We hypothesize that there might exist an inverted U-shaped relationship between operational efficiency and the cargo business ratio. When the actual ratio is lower than the optimal ratio, raising the cargo ratio may be beneficial. When the actual ratio is higher than the optimal ratio, raising the ratio may not.

Another competitive advantage of China is the abundant labor resource. Due to the huge population and the current stage of industrialization, the salaries of employees in China are much lower than in many other countries in the world, which can potentially affect Chinese airlines' operational efficiency in either way. On the one hand, lower salaries may help companies to cut their operational costs and improve their profitability, while on the other hand, lower staff costs may induce less attention to human resource management, which may lead to lower average employee productivity. Different labor employment strategies can be applied, depending on whether lower salaries improve the operational efficiency. If this is the case, then Chinese airlines would need to continue with their high labor intensive operations. If it is not, then

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changes may be needed. To our best knowledge, the effect of salaries on operating efficiency has not been investigated within the airline industry context, although the impact on profitability has been discussed.

The remaining of this paper is organized as follows. Following this introduction, Section 2 presents the methodology. Section 3 describes the data. The results are presented and discussed in Section 4 and finally Section 5 concludes.

2. Methodology

To investigate the impact of environment variables, we used a two-stage model when efficiency is measured in the first stage, and then regression is used to examine the effect of environmental variables on these efficiency scores in the second stage. In both stages, our data are treated as unpooled data. DEA permits the use of multiple inputs and outputs to measure a single efficiency score among decision making units (DMUs). In the first stage, we employed DEA to assess efficiency, using the measure of Technical Efficiency (TE) with the CCR model and Pure Technical Efficiency (PTE) with the BCC model. The ratio of TE and PTE enables the estimation for Scale Efficiency (SE). Input-oriented and output-oriented transformation for both CCR and BCC models exist. This paper selected the input-oriented DEA models because airlines have a better ability to control their inputs than outputs. Poorer control of outputs may be induced by macro-economic factors and market competition. Banker et al. (1984) provide more details of these models.

Typically, the second stage regression models can be formulated as follows:

$$\mathrm{TE}_i = \alpha + X_i\beta + \varepsilon_i \quad i = 1, 2, \ldots, n \tag{1}$$

α denotes the intercept, X_i is a vector of environmental variables for ith DMU, β is the coefficient which needs to be estimated and ε_i is error term.

Many researchers have estimated model (1) by employing Tobit regression (Fethi et al., 2000; Scheraga, 2004). However Simar and Wilson (2007) argued that such an approach to inference was invalid due to complicated unknown serial correlation. Firstly, the correlation between estimated efficiency values arises in finite samples because perturbations of observations lying on the production frontier will induce changes in the efficiency scores. Secondly, the estimated correlated efficiency scores have to be used in the second stage since the real values are unobservable, so the error term ε_i must be serially correlated. Thirdly, since the scores are affected by environmental variables, it can be inferred that the error term is correlated with the environmental variables. Therefore Simar and Wilson (2007) proposed the bootstrap procedure to improve statistical efficiency in the second-stage truncated regression for valid inference. This research employed their procedure in the second stage.

3. Data

When we selected the airlines, we considered three factors: data accessibility, the scale, and the characteristics, of operation. Specifically annual Revenue Tonne Kilometers (RTK) of our sample airlines had to be more than 5000 million and we only considered airlines operating providing both passenger and cargo service. This resulted in 12 airlines being chosen using operational data the years 2006–2010. These airlines are leading carriers in their respective countries or area, with four from China, two from other countries of Asian, three from United States and three from Europe. The data set was extracted from World Air Transport Statistics published by International Air Transport Association (IATA) and the annual reports of the sample airlines. To make our data comparable, we converted all financial data into China Yuan (CNY) at average exchange rates, which was the average of the twelve month IATA rates for the year reported.

Previous studies (Fethi et al., 2000; Scheraga, 2004; Barbot et al., 2008; Barros and Peypoch, 2009) have often measured inputs and outputs by different indicators. In this paper, we selected our indicator based on data accessibility and microeconomics principles. The inputs were measured by three indicators: number of full time employees, operational costs and number of aircraft. With respect to the number of aircraft, this is the total number of operational aircraft, including those that are fully owned and those that are under a finance lease or operating lease at the end of reported fiscal year. As regards outputs, we needed to capture outputs of both the passenger and cargo business which can be integrated into RTK measure. The operating revenue is another output indicator that captures the financial output. So our output indicators were RTK and operating revenue.

There are some conventional criteria for DEA applications. The number of DMUs should be at least the total number of input and output variables (Golany and Roll, 1989). In addition, the minimum number of DMUs should be equal to or larger than the product of the number of input and output variables (Boussofiane and Dyson, 1991). Our DMU observations meet both criteria, so the DEA approach was deemed valid.

In terms of the second-stage environmental variables, we focused on the environmental variables which have different values between Chinese airlines and the other airlines. Chinese airlines rely heavily on domestic transportation, so we investigated whether a shift from domestic business to international business improves efficiency. In order to capture the international focus of an airline, we designed a variable *INTER* which was calculated as the ratio of international RPK to total RPK. Secondly, although there is high demand for air cargo transportation in China, we examined whether a higher cargo business ratio improve efficiency. We used the variable *CARGO*, computed as the percentage of cargo revenue to the total operating revenue. To verify our hypothesis of inverted U-shaped relationship, we also introduced $CARGO^2$, which is the squared value of *CARGO*. Thirdly, we introduced the variable *SALARIES* which was the total staff costs divided by the number of full time employees to capture the average level of salaries. The total staff costs included wages, salaries, bonus, allowances and other welfare and benefits expense. Finally, we adopted a dummy variable *NATIONALITY*, taking the value of unity for Chinese airlines to examine the difference in operational efficiency between Chinese and foreign airlines.

Other relevant variables were also included in the regression model. *LOGPOPU*, *LOAD* and *FUEL* were employed to capture the influence of population, load factor, and utilization efficiency of fuel and oil on operational efficiency. *LOGPOPU* was defined as a log transformation of respective population. *LOAD* was computed as the percentage of RTK to Available Tonne Kilometers (ATK). *FUEL* was the ratio of total fuel costs to ATKs with the higher the ratio the lower the utilization efficiency.

Let i denote the ith airlines and t be a year between 2006 and 2010. Specifically, our regression model was formulated as follow:

$$\begin{aligned}\theta_{it} = {} & \beta_0 + \beta_1 INTER_{it} + \beta_2 CARGO_{it} \\ & + \beta_3 CARGO_{it}^2 + \beta_4 SALARIES_{it} \\ & + \beta_5 NATIONALITY_{it} + \beta_6 LOGPOPU_{it} \\ & + \beta_7 LOAD_{it} + \beta_8 FUEL_{it} + \varepsilon_{it}\end{aligned} \tag{2}$$