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Cost analysis of air cargo transport and effects of fluctuations in fuel price

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ABSTRACT

This study developed a model with cost functions formulated for different stages of cargo transport operation. A case analysis was performed with actual data from four air cargo traffic routes and eight aircraft types to validate the applicability of the model. The results show that the optimal payloads for various aircraft types vary with fuel price fluctuations. Furthermore, this study determined optimal types of freighter aircraft for different routes. Freight rates increase with rises in fuel price due to the corresponding increase in the fuel surcharge, thus bringing in higher total revenue. When the increase in total revenue exceeds the rise in fuel cost, the optimal payload will drop. Not only can the cost functions reveal the impact of fuel price fluctuations on different aspects of air cargo transport, they can also assist airlines in selecting the aircraft type with the best fuel economy for different route distances and cargo volumes.

1. Introduction

With the rapid developments in technology and new electronic products frequently appearing on the market, the past few decades have witnessed substantial growth in international air cargo transport under a closely linked global supply chain. Air cargo traffic increased from about 11 million tonnes in 1980 to about 49 million tonnes in 2011, an average growth of almost 4.9% per year; while seaborne trade only grew about 2.9% annually during the same time period.[1] According to the Boeing World Air Cargo Forecast (Boeing, 2012), global air cargo traffic will expand at an average annual rate of 5.2% for the next two decades.

Previous studies on the cost of air transport and choice of aircraft type have focused mainly on passenger traffic (e.g. Tsoukalas et al., 2008; Givoni and Rietveld, 2010; Takebayashi, 2011). Notable in the cargo area is Kupfer et al. who accounted for airport choice for freighter operations using the method of stated preference (2012a) and identified factors influencing airport choice of freighter operators using a multinomial logit model (2012b).

As with passenger transport, air cargo transport involves both direct and indirect operation costs. Direct operation costs are expenses associated with purchase or lease of aircraft and related equipment, as well as their maintenance fees; while indirect operation costs are expenses related to internal management and ground operations (see Fig. 1). In addition, the operation cost for each flight is made up of fixed and variable costs. Fixed costs, which do not change with flying distance, include expenses for landing, parking, security, and ground handling service charges. In contrast, variable costs, such as fuel cost, vary with the total mileage traveled.

Jet fuel is a major variable cost component in the operations of commercial airlines. Between 2004 and 2009, there were large fluctuations in jet fuel prices, with a marked three-fold increase between 2004 and 2008, followed by a rapid decline to the pre-2004 price level and then substantial increases again. Despite continuous efforts of airlines and aircraft manufacturers to enhance operation and product efficiency, what they achieved cannot match the fluctuations in jet fuel prices (Air Transport Association, 2008). In 2012, the airline fuel bill was expected to reach almost $200 billion, which was more than 30% of total operating costs (International Air Transport Association (IATA), 2012). Moreover oil will continue to represent a significant share of commodities traded because of increasing volumes, as well as expected price growth in the mid- to long-term (Airbus, 2012). This fuel price uncertainty is a major challenge facing the airline industry which has been researched, for example by Ryerson and Hansen (2010), who

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[1] Calculations made by Kupfer et al. (2012a) using data from the International Civil Aviation Organization (ICAO) and the United Nations Conference on Trade and Development (UNCTAD).

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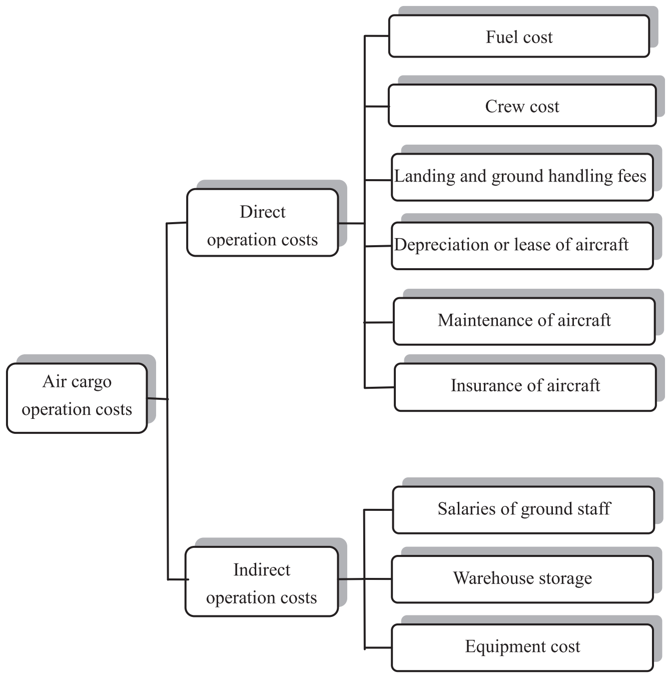

Fig. 1. Different types of air cargo operation costs.

evaluated the operation costs and passenger preference costs for different aircraft types over a range of fuel prices and route distances to determine the minimum cost for a fleet mix.

With growing development in air cargo transportation, there has been increasing research in this area but little has been done to explore the costs involved in different stages of operations in air cargo transportation. These costs include front- and rear-end operation costs, air cargo terminal cost, ground handling cost, airport service and equipment costs, as well as flight cost. This study proposes a model for examining the effects of fluctuations in jet fuel price on the cost of air cargo transport and the choice of freighters with different load capacities for different routes. Cost functions are formulated for different air cargo transport operations with variables including route distance, aircraft size and type, and airport charges. Not only can the cost functions reveal the impact of fuel price fluctuations on different aspects of air cargo transport, they can also assist airlines in selecting the aircraft type with the best fuel economy for different route distances and cargo volumes. A case analysis is performed with four air cargo traffic routes and eight aircraft types to validate the applicability of the formulated model.

The remainder of the paper is organized as follows. Section 2 describes the model formulation for air cargo transport cost functions. Section 3 validates the developed model and presents its applications. Conclusions drawn from the cost analyses and suggestions for future research are included in Section 4.

2. Model formulation

In this study, cost functions for the air cargo transport process, excluding road transport, are developed. From the shipper to the consignee, different operations are involved and respective costs are incurred. These costs include front- and rear-end operation costs, air cargo terminal cost, aircraft ground handling cost, airport service and equipment costs, and flight cost. Functions for these costs are established using mathematical modeling and are described as follows.

2.1. Front- and rear-end operation costs

Front- and rear-end operation costs include expenses for packaging and handling of shipments, document handling, Electronic Data Interchange, and so on, which are charged depending on the nature of the consignment and as a lump sum for the entire consignment. Hence, on average, the greater the cargo weight, the lower the front- and rear-end operation costs per kilogram. Let D_{mn} represent the front- and rear-end operation costs per kilogram of cargo transported from the departure airport m to the destination airport n, and the related cost function can be formulated as:

$$D_{mn} = (V_m + V_n)/q \quad (1)$$

where V_m and V_n denote related front- and rear-end operation charges per batch at airports m and n, respectively; and q represents the weight per batch of cargo.

2.2. Air cargo terminal cost

Costs incurred at the air cargo terminal include expenses paid for warehouse storage, container freight station (CFS) handling, and customs clearance. The total customs clearance fee comprises a goods examination fee; a quarantine inspection fee for agricultural, animal, and fishery products; and a fixed charge for customs clearance. Let A_{mn} represent the air cargo terminal cost per kilogram of cargo transported from departure airport m to destination airport n, and the related cost function can be formulated as:

$$A_{mn} = (B_m t_m + X_m) + (B_n t_n + X_n) \quad (2)$$

where B_m and B_n represents the storage cost per kilogram of cargo, t_m and t_n denote the average number of days the cargo is stored at the warehouse, and X_m and X_n are the handling and customs clearance fees per kilogram of cargo at airports m and n, respectively.

2.3. Aircraft ground handling cost

Prior to take-off from the departure airport, cargo containers need to be loaded onto the freighter aircraft and the aircraft require pushback or towing and guidance into position. The costs incurred for using the facilities for handling these operations vary with the type of aircraft. Let E^f_{mn} represent the aircraft ground handling cost per kilogram of cargo transported on aircraft type f from departure airport m to destination airport n, and the related cost function can be formulated as:

$$E^f_{mn} = F^f_m + \left[(Q_m + Q_n)e^f\right] \Big/ \rho^f_{mn} l^f_{mn} \quad (3)$$

where F^f_m denotes the pushback or towing cost for aircraft type f at the departure airport m. Let Q_m and Q_n represent the cost for loading and unloading each cargo container at airports m and n, respectively. e^f is the average number of containers that can be loaded onto aircraft type f. Let ρ^f_{mn} and l^f_{mn} represent the average load factor and load capacity of aircraft type f from departure airport m to destination airport n, respectively.

2.4. Airport service and equipment costs

Fees are paid by airlines for using the services and facilities at airports. Examples of such fees are landing charges for use of the runway and parking, terminal charges for use of the airport infrastructure, security charges, noise charges for protection of the environment, and air traffic control charges for en route navigation.