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Economies of traffic density and scale in the integrated air cargo industry: The cost structures of FedEx Express and UPS Airlines

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A B S T R A C T

This paper examines the cost structures of the leading integrated air cargo carriers, FedEx Express and UPS Airlines. A total cost model is estimated for the two carriers using quarterly data on domestic operations and costs over a nine-year period (2003–2011). The estimated model indicates that the integrated industry exhibits increasing returns to traffic density and constant returns to scale. Accounting for carrier-specific differences in cost structure and network size, FedEx Express is found to be more cost-efficient than UPS Airlines. Looking at the carriers individually, UPS Airlines exhibits substantial economies of traffic density and constant returns to scale while FedEx Express' cost structure is characterized by weak economies of density and constant returns to scale. The combined effect of returns to density and returns to scale on the cost structures of integrated carriers is captured by economies of size. Both FedEx Express and UPS Airlines exhibit economies of size, indicating that carriers in the integrated industry can be more cost efficient by making appropriate adjustments to their network size as their output grows. Moreover, the relative cost-efficiencies of the carriers are reversed when their network-size differences are not controlled.

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1. Introduction

In view of the air cargo industry's considerable growth in transported cargo and express services, this study investigates the cost structures of the leading integrated carriers, FedEx Express and United Parcel Services (UPS) Airlines, to find empirical evidence on economies of traffic density and economies of scale in the integrated air cargo industry.[2] Much of the air cargo literature is naturally adapted from studies on passenger airlines, which suggest that (1) costs per passenger-mile decrease with traffic density on individual airline routes (2) both major and local carriers exhibit constant returns to scale (Caves et al., 1984; Gillen et al., 1990; Brueckner and Spiller, 1994). Air cargo analysis by Kiesling and Hansen (1993) has shown that increasing returns to traffic density and decreasing returns to scale held for FedEx Express in the 1980's and early 1990's.

Analyzing quarterly time-series data from 2003 to 2011, this paper shows that the domestic (United States and Canada) integrated industry exhibits increasing returns to density and constant returns to scale. The combined effect of economies of density and economies of scale on the carriers' cost structure is captured by *economies of size*, a measure introduced to the air cargo literature by Kiesling and Hansen (1993). Controlling for carrier-specific differences in network and input-price attributes, this study shows that the integrators exhibit increasing returns to size.

Although the air cargo industry was deregulated a year before the passage of the Airline Deregulation Act (November 9, 1977), its deregulation has not sparked nearly as much research interest as deregulation of the passenger airline industry. Despite the thinness of the air cargo literature, and the limited knowledge of the industry due to sparse data, there has been a gradual shift of attention towards it in the past decade. Still, the industry's distinctive cost structure and success in servicing a range of domestic and international markets remains unappreciated. Some of the earliest works that address economies of density and scale in the air cargo industry are by Smith (1974) and Carron (1981). Since deregulation, cost-structure studies of the passenger airline industry continued to examine the nature of density and scale economies. Caves et al. (1984) found that there are substantial economies of density for

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[2] Integrated carriers provide all-inclusive parcel shipping services, from forwarding and flying to ground handling. Considering the dominant presence of FedEx Express and UPS Airlines amongst integrators, both in terms of traffic volume and revenues, the two carriers are assumed to represent the entire integrated industry in this paper.

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carriers of all sizes. They showed that total cost increases 80 percent as rapidly as total traffic, holding the number of points served fixed. They also found that constant returns to scale held for major and local carriers. The latter conclusion, however, negated previous beliefs about cost differentials between major (trunk) and local carriers, assuring that local carriers could compete with airlines that operate larger networks. Brueckner and Spiller (1994) found stronger estimates of economies of density by taking a more disaggregated approach that uses a structural model of hub-and-spoke airline competition.

Recognizing the need for a similar empirical analysis of the air cargo industry, Kiesling and Hansen (1993) characterized the cost structure of the largest integrated air cargo carrier at that time, FedEx Express (then Federal Express, Inc). They showed that FedEx Express, and conceivably the rest of the all-cargo carriers in the industry, exhibits substantial economies of density and diseconomies of scale. The authors also introduced a third aspect of the industry's cost structure, economies of size, that combines the effects of economies of density and economies of scale. They found that FedEx Express exhibits constant returns to size, implying that costs rise in proportion to output when the network size is adjusted in step. This result supported their view that FedEx Express could expand its output and network size without sacrificing efficiency, an outcome that presumably requires network size to increase less than in proportion to output so as to exploit economies of density. Therefore, economies of size captures the effects of increasing output levels while adjusting the number of airports served (points served), assuming that output and points served are functionally related.

FedEx Express has expanded its operations and markets at a remarkable pace since Kiesling and Hansen's (1993) study. Just as Caves et al. (1984) reexamined the widely held beliefs about the cost advantages of major carriers in the passenger airline industry, the following analysis will attempt to characterize the current cost structures of the two most dominant air cargo carriers, FedEx Express (FedEx hereafter) and UPS Airlines (UPS hereafter). The broader implications of this study will also be useful for policy-related questions regarding cost efficiencies in the air cargo industry. Specifically, the study will provide a baseline framework to understand the cost factors that are involved in network-size and traffic-allocation decisions. Considering that the current understanding of the air cargo industry is mostly based on analogies drawn to passenger airlines, it is important to distinguish the unique characteristics of air cargo operations and to fill in the corresponding literature gaps along the way.

While studying the cost structure of the entire air cargo industry would be a useful exercise, the distinctive operational characteristics of FedEx and UPS require an analysis focusing on them alone. Specifically, integrated carriers consolidate the supply chain of cargo transportation, from the consignor to the consignee, according to their own schedule. Other dedicated air cargo or passenger-cargo (combination and belly freight) carriers mostly offer chartered services for shippers, forwarders, and third-party logistics providers. Moreover, data from the U.S. Department of Transportation (DOT) show that FedEx and UPS respectively transported 53 and 29 percent of the total domestic cargo tons enplaned by U.S. carriers over the past decade. Together, the two carriers also accounted for just over 90 percent of all international air freight ton-miles in 2008 (see Morrell, 2011, p. 99). With operating revenues over $1 billion, FedEx and UPS are the only cargo carriers officially classified as Group III carriers by the DOT, further distinguishing them from the rest of the air cargo industry. Therefore, this study will primarily focus on these two carriers to represent the integrated air cargo industry.

It should be noted that, despite the many perceived similarities between FedEx and UPS, the carriers have fundamental differences in demand, network characteristics, and operations that affect their cost structures. FedEx specializes in expedited delivery of business-related small packages and letters, using a large air fleet on feeder, point-to-point, and hub-and-spoke networks. UPS operates a multimodal network of trucks and air freighters for delivery of packages to businesses and personal customers. A sizable portion of UPS's traffic is transported by ground vehicles. Thus, while there is a need to analyze the integrated industry, a proper study must shed light on the differences between the firms.

1.1. Background

Air freighters used a single hub city (airport) for sorting in the early stages of the air cargo industry (Noviello et al., 1996). Over the years, increasing demands have led carriers to incorporate more hubs into their networks. Both FedEx and UPS now operate nine domestic hubs that are dispersed across the U.S. and Canada. FedEx is based at Memphis International Airport, its largest hub (*Superhub*). The other domestic hubs for FedEx are Fort Worth Alliance, Indianapolis International, Newark Liberty International, Oakland International, Ted Stevens Anchorage International, Piedmont Triad International (Greensboro), Miami International, and Toronto Pearson International (Canada). UPS operates from its Louisville International Airport hub (*Worldport*) as well as the following additional domestic hubs: Philadelphia International, Los Angeles/Ontario International, Dallas-Fort Worth International, Chicago Rockford International, Bradley International (Hartford), Miami International, Columbia Metropolitan (South Carolina), and Hamilton International (Canada).[3]

Even though air cargo carriers operate hub-and-spoke networks like passenger airlines, the nature of their hub-and-spoke systems is different. Air freighters typically transfer a larger proportion of their traffic through a relatively small number of hubs in their network. Parcels being transported are not sensitive to multiple stops and circuity, so they can be flown in a manner that allows carriers to operate their hub-and-spoke system most efficiently (Kiesling and Hansen, 1993). However, flying cargo naturally involves other costly operations that are not characteristic of transporting passengers. These operations include transshipment, pallet assembly and disassembly, and the handling of parcels during aircraft changes. Demand asymmetry is also inherent in air cargo networks since, unlike passengers, goods being transported do not make round-trip flights. Goods are generally flown one-way, from manufacturers to retailers, and to consumers (Zhang and Zhang, 2002).

Air cargo network structures and hub location have been studied using a variety of approaches. O'Kelly and Miller (1994) provide a detailed review of passenger-airline and air cargo network designs. The authors evaluated research on hub-and-spoke assignments, spoke-to-spoke connections that bypass hubs, and the interconnectivity of hubs. A more pertinent study by Kuby and Gray (1993) also challenged the traditional understanding of hub-and-spoke networks, with particular attention paid to FedEx. Kuby and Gray showed that FedEx does not serve all cities with direct flights to and from hub cities; instead feeder aircraft are used to service smaller cities while also making intermediate stops at other points in the carrier's network before flying to a hub. Their work provides the underlying framework that will be used to measure the network size of the integrated carriers in this study. More recently, Bowen (2012) provided a comprehensive overview of the spatial network characteristics of FedEx and UPS.

The air cargo industry has changed considerably since Kiesling and Hansen's (1993) study. Air express, in particular, has been the

[3] See Bowen (2012) for major-hub timelines of FedEx and UPS.

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