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Overview Paper

Air cargo operations: Literature review and comparison with practices

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ABSTRACT

This study reviews the literature on air cargo operations and compares theoretical studies with the practical problems of airlines, freight forwarders, and terminal service providers. In particular, we review studies in which mathematical models were used to identify the essential characteristics of air cargo operations, such as the intrinsic differences from passenger operations, and to explore the service processes in air cargo operations. The typical models used in previous studies are summarized. We then highlight the insightful findings from an industrial interview and present the gaps between previous research and practical realities. We finally discuss the new research opportunities of air cargo operations according to the gaps.

1. Introduction

With increasing globalization, the air cargo industry has continued to serve as a key facilitator of world trade and has doubled in volume every 10 years since 1970 (Chang et al., 2007). Goods transported by air account for 36% by value of all goods traded globally (IATA, 2006). Worldwide, air cargo transport has grown about 50% faster than passenger transport during 1995 and 2004 (Wong et al., 2009) and continues to grow in recent years. Air cargo transport is becoming a significant revenue source for airlines (Han et al., 2010; Nobert and Roy, 1998), whose profit has climbed to 40% in average in 2009 from about only 5% in 2000. Boeing (2014) forecasts that the air cargo market will continue to grow by 4.7% per year and will triple in revenue by 2033 from 207.8 billion revenue ton kilometers (RTKs) in 2013 to over 521.8 RTKs in 2033 (see Fig. 1). This growth is largely attributed to the expansion in Asian markets, particularly in China, as shown in Fig. 2 (Petersen, 2007). Several factors drive this dramatic growth, including the rapidly growing global trade, the high demand for fast and timely delivery, and firms' efforts to keep a low inventory through frequent replenishments (Li et al., 2009; Ou et al., 2010).

Airlines are challenged to manage their air cargo operations efficiently by developing strategic operation plans that allow these airlines to promptly adapt and respond to changes in the global competitive environment (Nobert and Roy, 1998; Ferguson et al., 2013). In response to such challenges, an increasing amount of theoretical research has been conducted to address the problems in air cargo operations since the 1990s. However, most problems, real-world problems in particular, remain unsatisfactorily solved, partly because of the complexities of air cargo operations. Therefore, this study aims to present the challenges faced by the air cargo transport industry through a comprehensive review of the literature on all aspects

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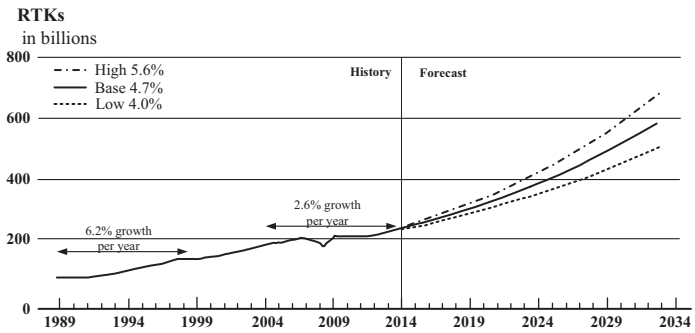

Fig. 1. Growth of world air cargo.

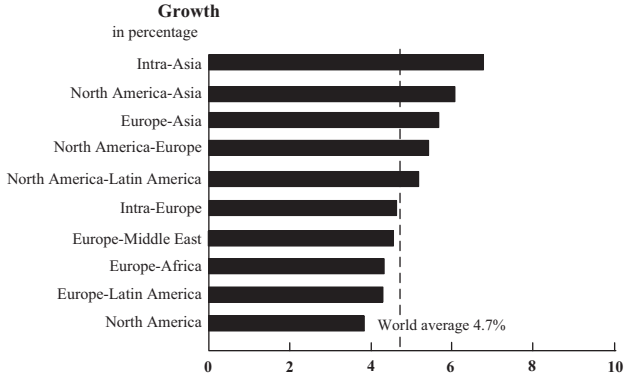

Fig. 2. Asian cargo markets continue to lead industry growth.

of air cargo operations and through a comparison of previous theoretical research with practical realities. In particular, we aim to develop a big picture of air cargo operations to show the highly interdependent decisions among many interfaces and players.

The rest of this paper is organized as follows. Section 2 describes air cargo transport processes and identifies their latent features. Section 3 categorizes and tabulates the air cargo literature. Section 4 presents real-world decision problems in the air cargo industry. Section 5 highlights the gaps between academic research and realities and then suggests new research opportunities. Section 6 presents the summary.

2. Overview of air cargo operations

Air cargo transport involves a series of services from origins to destinations to move cargo through a *shipper*, a *forwarder*, a *road transporter* (or trucker), an *airline* (or carrier), and a *consignee* (Derigs et al., 2009). The shipper needs the commodity to be sent anywhere in the world at a low cost and at the required service level. The forwarder acts as the "middle man" between the shipper and the airlines. The road transporter provides the ground transportation services before and after air transport. The airline receives, stores, transfers, tracks, loads and unloads cargo, and assigns and manages capacity. The consignee receives the shipment. Fig. 3 depicts the air cargo transport processes (Kasilingam, 2003).

Two types of airlines are involved in this service supply chain: integrated express carriers and passenger and cargo combination airlines. Combination airlines may carry air freight, express packages, and mail in the belly space of passenger aircraft and operate dedicated freight aircraft (Li et al., 2012). Some combination airlines may also run "combi" aircraft whose cargo capacity is adjustable through the removal or addition of passenger seats. All-cargo carriers consist of integrated express carriers (e.g., FedEx, UPS, and DHL) and non-integrated freight carriers.[1] Integrated express carriers mainly sell capacity to shippers directly (direct channel market), but they also sell excess capacity to freight forwarders (indirect channel market). In the indirect channel market, integrated express carriers and non-integrated ones share the same supply chain structure, and they face mostly the same decision problems. In the direct channel market, the decision problems for integrated

[1] All-cargo carrier provides express/small packages services with dedicated freight aircraft in a door-to-door manner using its own air and ground fleet to process the entire shipment. Non-integrated freight carriers provide services for bulk and heavy shipments using dedicated freight aircraft through collaborations with freight forwarders.