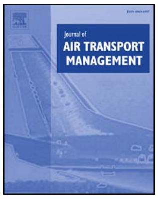
Journal of Air Transport Management 69 (2018) 123–136

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman



A decision making tool considering risk assessment of sub-contracting agents for an air cargo shipment planning problem

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ARTICLE INFO

Keywords:
Air cargo
Shipment planning
Risk assessment
Heuristics

ABSTRACT

Development of an efficient shipment plan for air cargo forwarders is a critical to obtaining considerable integration and consolidation savings and to meeting competitive requirements such as target costs. In this paper, we propose a decision making tool to solve a deterministic air cargo shipment planning problem with risk assessment of sub-contracting agents evaluating possible consolidations and integrations. The decision making tool consists of a risk assessment module based on historical data and a shipment planning module that includes a genetic algorithm (GA). Various benchmark instances are generated based on real life data obtained from a worldwide air cargo company to investigate the performance of the proposed methodology. In conclusion, the proposed methodology provide effective solutions in terms of solution quality and computational time.

1. Introduction

Air cargo shipment has taken on an important role in world trade as the airline industry has developed dramatically. According to a world air cargo forecast report by Boeing, air cargo market growth has doubled every ten years since 1970. In spite of the global economic crisis of 2007–2011, world trade volume has increased in recent years and the share of air cargo trade has grown accordingly. For this reason, there has been a rapid increase in the number of papers offering solutions for the problems of cargo loading, workforce planning, routing, flight planning. A review of scientific literature on the issue reveals, however, that there is still limited research addressing the air cargo shipment planning problem that includes consolidation and integration.

Airfreight forwarders conduct cargo shipments for their clients. Airfreight forwarder companies, who manage multi-model transport best, provide transport logistics with their own supplies, partners and sub-contractors (Wong et al., 2009). In addition to providing the best service, these companies need to be effective in order to compete with the others (Yoon and Park, 2015). An airfreight forwarder considers the optimum cost when operating activities during the shipment planning process. Integration and consolidation are possibilities that can ensure a cost reduction in the process. Consolidation refers to carrying out shared activities of multiple jobs by one agent while integration refers to combining consecutive activities within a job.

Airfreight forwarders need to consolidate jobs effectively and minimize shipment costs while meeting customer needs. The structure of airfreight rate is highly complex in consolidation which presents a difficult mixed integer programming (MIP) problem for the airfreight forwarder (Huang and Chi, 2007). According to Hall (1987) and Higginson and Bookbinder (1994), consolidation has three dimensions: freight consolidation, time consolidation and route consolidation. The airfreight forwarder problem formulated by Huang and Chi (2007) defines MIP for a deterministic demand from a single-point. A new method is developed using Lagrangian Relaxation to solve the problem. With regard to experimental studies, this method provides respectable results. Thus, the solution algorithm is found appropriate for air cargo consolidation problems to be used as a core module in the decision support system. The consolidation problem is a matter of fact in air transport as well as in maritime transport. Ang et al. (2007) deals with the ocean-cargo shipping problem for international sea container shipping by emphasizing the concepts of weight, volume and cost depending on the weight in shipping. Characteristics of the ocean-cargo shipping problem are defined and the problem is formulated as a multi-dimensional multi traveling salesman problem. Li et al. (2012) develops a model in which the amount affects cost by considering weight and volume constraints. The developed model takes into account many characteristics such as multi-origins and multi destinations, capacity constraints in flight network, economies of scale for each flight, weight and volume capacities, departure and arrival times of flights, and setup and delivery times of each shipment. Chan et al. (2012) propose agent-based flight planning system focusing on cargo consolidation and equalization to facilitate process automation for the air cargo industry.

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https://doi.org/10.1016/j.jairtraman.2018.02.005
Received 28 July 2015; Received in revised form 21 February 2018; Accepted 22 February 2018

The aim of the software is to assist freight forwarders by automatically recommending flight plans based on the latest air cargo information. As consolidation at hubs in a pure hub-and-spoke network eliminates partial center-to-center direct loads and decreases transportation costs, the capacitated p-hub median problem is solved to select an exact p among a set of candidate hubs. Lin et al. (2012) develop a genetic algorithm to solve the presented integral-constrained p-hub median design problem with economies of scale. They study Chinese air networks and report that the airports with high pickups or delivers are prime candidates to be designated as hubs. In addition, air carriers must take into account bundling options for shipments that are delivered at outstations and have to be moved to the hub. Rezaei et al. (2017) present a multi-criteria decision-making tool to decide the best configuration with respect to the tree KPIs namely cost, (un)loading time and quality. After applying the method to a case study at KLM cargo, authors indicate that trucking cost and freight handling tariffs at the outstations are key factors in determining optimal alternative. Nowadays freight forwarders should also consider unexplored opportunities for horizontal collaboration in landside airport transport, due to the global economic crisis of 2007–2011. Ankersmit et al. (2014) propose a simulation based method for transport collaboration and Schiphol airport is selected for a case study to show the key effects of applying horizontal collaboration to inner-airport transport air cargo shipments. Proposed simulation model shows that horizontal transport collaboration can improve the performance of freight forwarders.

Wong et al. (2009) examine the effects of consolidation and integration with time, volume and weight constraints in the air cargo shipment planning problem. In the paper, focusing on a target delivery time, a target cost and transport capacity constraints, and a model for minimizing the shipping cost is proposed by using Tabu Search Algorithm (TS). Leung et al. (2009) also solve a similar model by using Branch and Bound Algorithm and heuristics. Wong et al. (2009) and Leung et al. (2009) aim to create a minimum cost shipment plan by dividing the jobs into activities and generating the most appropriate agent assignment to carry out those activities. Chow et al. (2013) also develop a multi-agent system with decision supports and mobile information retrieval functions for the problem of freight planning. A simulated annealing algorithm and a fuzzy-logic for the proposed methodology are implemented. In order to provide a reliable shipment plan, Leung et al. (2013) proposed a three-phase decision tool for managing third-party logistics under uncertainty. TS is used to determine a tentative shipment plan in phase one and then reliability of the plan is examined using a simulation model. Finally, specific actions are applied to revise the unsatisfactory shipment plans. The paper focuses on the reliability of a shipment plan in an uncertain environment. Hui et al. (2014) propose a two-stage stochastic programming approach to solve the air cargo shipment planning problem under uncertainty. A profit maximization model is considered to develop the optimization start-up shipment plan using two-level echelon solution algorithm. TS is used at the upper level to provide the optimal shipment plan. Hui et al. (2014) and Leung et al. (2013) consider tardiness of jobs for the shipment plan in an uncertain environment. Furthermore, random processing times of activities and also random constraints of delivery times are regarded in these papers. Feng et al. (2015) review the literature on air cargo operations and compare theoretical studies with the practical problems of airlines, freight forwarders, and terminal service providers. Merkert et al. (2017) organize a special issue that contributes to solve the problems of current air freight. They remark that the consolidation trend among suppliers of freight is continuing unabated and this trend also results in constant shifts in the value chain.

Within these papers, however, there was no attempt to define risk factors in a deterministic model that considers the number of tardy activities, shipment safety (including damaged or missing freights), and the competency level of an agent according to historical data. This paper focuses on an air cargo shipment planning problem that includes risk assessment of sub-contracting agents and the effects of consolidation and integration with capacity of agents, target cost, and time constraints. To our knowledge, this is the first research paper where a decision making tool is proposed to solve a deterministic airfreight forwarder shipment planning problem with risk assessment of sub-contracting agents evaluating possible consolidations and integrations. The decision making tool consists of a risk assessment module based on historical data and a shipment planning module including genetic algorithm (GA) methodology. Various benchmark instances are generated based on real case data obtained from a worldwide air cargo company to investigate the performance of the proposed methodology.

The rest of this paper is organized as follows: in the next section, a detailed description of the air cargo shipment planning problem with risk assessment of agents is given. Section 3 presents the structure of the proposed methodology. Section 4 describes the numerical investigation carried out to evaluate the performance of the proposed methodology. The paper concludes with a summary and suggestions for further research.

2. An air cargo shipment planning problem with risk assessment of agents

An airfreight forwarder intends to carry out jobs with partners (agents) who have the capacity to complete all or some of the activities that take place between supply and delivery. The airfreight forwarder receives the cargo from the customer and delivers it to the target destination. In order to manage that, some activities need to be processed such as receiving the cargo, transporting it to the airport via highways, warehousing it, delivering it to the target destination by airway, warehousing it temporarily at the destination point, and then transporting it to the last point via highways.

An airfreight forwarder company fulfills all jobs via the above mentioned set of activities. However, the airfreight forwarder does not process all of the activities using its own resources. Most activities are processed by partners called agents. For instance, transporting goods to the airport can be carried out by one sub-contracted agent, transporting those goods from one airport to another can be done by a second agent, and transporting the goods from the airport to the target warehouse via highways can be processed by a third agent. In this case, the airfreight forwarder works with three different agents to make it to the last point (Fig. 1).

An airfreight forwarder considers the optimum cost when choosing agents to partner with. The best agent-activity matching should be done considering the target costs, delivery time, and weight and volume capacities of each agent. Setup and processing costs are considered in the cost calculation. Similarly, the setup and processing time for each activity are taken into account in the calculation of delivery times. Integration and consolidation are other possibilities that can ensure a reduction in shipment planning process costs.

Consolidation refers to carrying out shared activities of multiple jobs by one agent while integration refers to combining consecutive

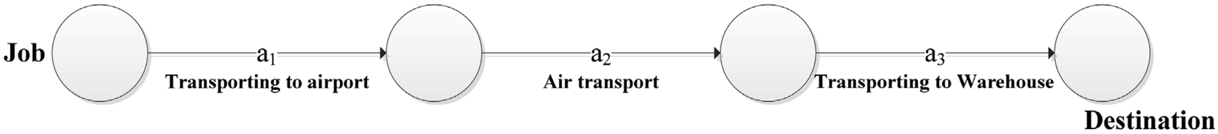

Fig. 1. Activities (a_1, a_2 and a_3) processed by agents.