1-Hub or 2-Hub networks?

A Theoretical Analysis of the Optimality of Airline Network Structure

Xiyan Wang
Department of Economics, UC Irvine
02/01/2015

INTRODUCTION

The Hub-and-spoke (HS) network has been the focus of airline network studies since US airline deregulation. Abundant literature exists on airline networks, and the cost and demand conditions of an airline are the main determinants of network choice. Using linear marginal cost functions \( MC = 1 - \theta Q \), most theoretical work relies on a high value of returns-to-density parameter \( \theta \) to guarantee optimality of the HS network (\( Q \) is traffic). As a number of theoretical studies have pointed out, each additional hub in the network reduces the cornerstone of the hub strategy, density economies. Moreover, additional hubs also incur complexity costs (Duedden 2006; Wojahn 2001a&b).

On the other hand, the arguments that a single-hub network is the only optimal solution do not explain the reality where the multi-hub network structure is popularly adopted by most of today’s airlines. Studies advance several arguments trying to explain the existence of multi-hub networks. So far, theoretical settings with networks of arbitrary size and structure have found no evidence for multi-hub networks existing as a result of cost-minimizing behavior under symmetric cost functions (Hendricks et al. 1995, Wojahn 2001). As a result, there is little theoretical basis to evaluate the current literature’s informal explanations of the existence of multi-hub networks. Looking beyond cost issues and economies of density, and including demand-related aspects to find a justification for multi-hub networks, Düdden (2006) used a simple theoretical model with exogenous price and demand. The model gives justification for the rationality of multi-hub networks with one large and one small hub, yet cannot explain a strategy of equal-size hubs, suggesting the need for the present generalization.
METHODOLOGY AND RESULTS

To focus on the effect of network structure on profit, this paper constructs a simple and general model based on the monopoly case, aiming to explicitly investigate the optimality of single-hub (1H) versus 2-hub (2H) networks (as depicted in Figure 1). The model shows that, using a functional specification that is quite common in the literature, economies of density do not guarantee optimality of the 1H network, and that the 2H network is more profitable in a large proportion of the feasible parameter space as depicted in Figure 1 below, where $\alpha$ is the intercept for the demand curve and $\theta$ denotes the economies of density parameter.

To be more specific, the 2H network is preferred over the 1H network if demand and economies of density are both low. Moreover, if economies of density are weak, then the 1H network cannot dominate the 2H network unless...
demand is strong enough. On the other hand, if economies of density are strong, then the 1H network may be more profitable than 2H even if demand is low.

After establishing the above results, the paper also analyzes an airline’s choice between the 1H and 2H networks under Cournot duopoly, where a network airline is competing with a low-cost carrier (LCC). Operating under a different business model, LCCs offer point-to-point connections especially from spoke cities. According to Franke (2004), LCCs have already reached some 9% market share in the US domestic market in terms of revenue (24% in terms of passengers) and are rapidly growing. Facing such a great challenge, it is crucial for the network carriers to come up with new strategies and respond to this new competition.

Interestingly, the model reveals that the ongoing consolidation and reshaping of the hub landscape could be the result of network carriers responding to LCC competition, since it is more profitable for the network carriers to switch to 2H when confronted with an LCC challenge. The model shows that given symmetric markets, linear marginal costs with 4 nodes and no connecting time cost, LCC entry connecting one pair of the spoke cities (as in Figure 3) shrinks area of the feasible parameter space and reduces the percentage of the feasible space favoring the 1H network from 45.4% to 43.5%. Hence, the network carrier is more likely to choose the 2H network after LCC entry.

With an LCC connecting previously unconnected airports, part of the connecting market that once belonged to the monopolistic airline is “stolen”. While the 1H network reduces cost per passenger by allowing the operation of larger aircraft, this traffic-collection role becomes less crucial when the connecting markets shrink. Contrary to the 1H network, the 2H network relies more heavily on direct routes, so that the loss of market share to an LCC does not reduce its profit as much.
Reference


