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Network effects, heterogeneous time value and network formation in the airline market

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ABSTRACT

This study examines an airline firm's adoption of a hub–spoke network or a point-to-point network when considering network effects from the demand side and the heterogeneity of passengers' time value.
The results of this study reveal the following: If the time value for leisure passengers is sufficiently small and the operating cost is medium or when the time value for leisure passengers is high and operating cost is small, the monopoly airline adopts a hub–spoke network. Otherwise, a point-to-point network is adopted. Moreover, even when the airline chooses a point-to-point network, business passengers might move via another city according to second-degree price discrimination.

1. Introduction

This paper elucidates an airline firm's adoption of a hub–spoke network or point-to-point network when considering network effects from the demand side and the heterogeneity of time value for passengers. To date, studies related to hub–spoke networks have adopted the supply perspective. These studies devoted particular attention to economies of density, implying that the marginal cost decreases with demand. We term this the network effect.

A representative paper that explores economies of density is Brueckner and Spiller (1991). For the adoption of a hub–spoke network, they use a quantity decision model to examine whether monopoly or competition is socially optimal. Hendericks et al. (1995) demonstrate that an airline firm adopts either a hub–spoke or point-to-point network when economies of density prevail. They conclude that a socially optimal network is a hub–spoke network with only one hub or a complete point-to-point network.

It is noteworthy that network effects exist not only for suppliers, but also on the demand side. The network effects of the demand side would mean that when an airline firm increases the flight frequency, the benefit to passengers increases because they can enjoy the convenience. This paper mainly addresses these points. Some precedent papers, namely, Berechman and Shy (1996) and Marumo (2004), also discuss this point.

Berechman and Shy (1996) consider a situation including a monopoly airline firm and homogeneous passengers. The airline firm chooses a network formation, flight frequency, and price. Each passenger gains extra benefit when using a point-to-point network because of the time reduction. Berechman and Shy (1996) show that if this extra benefit is large, then the airline firm chooses a point-to-point network. If it is small, then the airline firm chooses a hub–spoke network. In addition, we observe the

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following characteristic in Berechman and Shy (1996): If the marginal operating costs are high, then the airline firm adopts a point-to-point network; if the marginal operating costs are low, then the airline firm adopts a hub–spoke network.

Marumo (2004) analyzes the model advanced by Berechman et al. (1998), which includes an examination of the network effect, indicating that if the increased revenue accrued by the network effect is greater than the increase in operating costs, then the airline firm adopts a hub–spoke network. However, this analysis addresses only one city-pair market.

In addition, Brueckner (2004)[1] and Oum et al. (1995) include both types of network effects (economies of density and network effects with the demand side). Brueckner (2004) reviews monopolistic airline firms and passengers with heterogeneous benefits and concludes that the airline firm determines the network formation, flight frequency, and quantity. Brueckner (2004) does not suggest a clear conclusion with respect to the airline firms' decisions regarding network formation. If the total flight frequency for a hub–spoke network is less than that for a point-to-point network, an airline firm chooses a hub–spoke network when the marginal operating cost is high, and a point-to-point network when the marginal operating cost is low. Conversely, when assuming that the total flight frequency for a hub–spoke network is higher than for a point-to-point network, the airline firm chooses a hub–spoke network if operating costs are small. If operating costs are high, then the airline firm chooses a point-to-point network, which is a conclusion similar to that of Berechman and Shy (1996).

Oum et al. (1995) examine the network structure problem considering the duopoly situation. Their paper uses a general cost function and demand specification; the results show that airlines will prefer a hub–spoke network if the airline's total costs and marginal cost for connecting passengers do not increase.[2]

As explained in Berechman and Shy (1996), Brueckner (2004), Marumo (2004), and Oum et al. (1995), all passengers move between cities directly when a point-to-point network is adopted. However, in the actual world, even if a point-to-point network is adopted, some passengers move between cities via a hub city because this route is more conventional. This reason is inferred to reflect the heterogeneity of time value. For example, business passengers wish to arrive at their destination using a prompt and reliable flight service. For this reason, they might prefer a more conventional route. On the other hand, leisure passengers might not be concerned about the arrival time: they might therefore choose a direct route.

This study adopts the method of Shy (1995) chapter 17.2, in which a monopoly airline is assumed[3] with two passenger types: a business passenger and a leisure passenger. Although this setup is identical to that of Berechman et al. (1998)[4] and Marumo (2004), the interpretation is different. For the present study, we assume that business passengers prefer to arrive as near as possible to the time that they expect to arrive. Leisure passengers are unconcerned about the arrival time. For this reason, while business passengers prefer a high flight frequency, leisure passengers are relatively less concerned about flight frequency.

When two types of passengers exist, the airline can adopt a price discrimination strategy (second-degree price discrimination) if it chooses a point-to-point network. This strategy enables some passengers to move directly and other passengers move via another city. However, these possibilities have not been examined in previous studies on airline network formation. Therefore, this paper contributes to the literature by incorporating to the possibility described above into the analysis.

Is it profitable for an airline to employ second-degree price discrimination? Although various studies in second-degree price discrimination have been conducted[5], they do not consider how consumers' (or passengers') decisions influence network effects. This paper illustrates that second-degree price discrimination can be adopted to discriminate between business passengers and leisure passengers and to increase network effects and multiply airline profits. On the other hand, cases in which an airline does not undertake second-degree price discrimination also exist.

These differences mainly depend on the time value of leisure passengers[6]. Disregarding passenger types, all passengers always move similarly or directly between cities, as described in earlier studies. However, considering the passenger types, if the time value of leisure passengers is low, business passengers' routes can differ from leisure passengers' routes due to price discrimination; in other words, business passengers choose a route that is via another city and leisure passengers choose a direct route. Therefore, this study reflects important characteristics and presents them in this paper as novel insights.

Moreover, considering the situation presented above, this study examines whether it is more profitable for the airline firm to adopt a hub–spoke network or to adopt a point-to-point network. In other words, which network formation does an airline firm choose? The results presented in this paper show that if the time value for leisure passengers is sufficiently small and if operating costs are medium, or when the time value for leisure passenger is larger and operating costs are low, the monopoly airline adopts a hub–spoke network. Otherwise, a point-to-point network is adopted. In particular, if we disregard the heterogeneity of the passengers' time value, when operating costs are low, an airline always chooses a hub–spoke network. However, if this heterogeneity is considered, when leisure passengers' time value is small and operating costs are low (except for the case in which the time value of leisure passengers is sufficiently low and operating costs are moderate), the airline adopts a point-to-point network to discriminate between business passengers and leisure passengers. These findings are the main conclusions presented in this paper.

In addition, this paper derives a socially optimal network formation and compares it to a market outcome. The results demonstrate that a monopoly airline firm has an inadequate or an excessive incentive to adopt a hub–spoke network.

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[1] This paper generalizes the framework of Brueckner and Zhang (2001).

[2] This paper's conclusions also depend on some assumptions regarding the cost function or demand function.

[3] Here, we must stress one important problem. This paper's model ignores economies of density and instead emphasizes the examination of passenger types according to their valuation of time. However, as Pels et al. (2000) argues, economies of density also have an important role for network structure; consequently, in future studies, we must include economies of density.

[4] Their paper does not introduce both types of network effects.

[5] See Deserpa (1986), Tirole (1998), Gabrielsen and Vagstad (2003), Weichenrieder (2004) et al. for details on second-degree-price discrimination.

[6] The airline discriminates in pricing if the time value of leisure passengers is low. Otherwise, an airline does not do so.