Airport Congestion Pricing: Effects of Terminal Congestion, Passenger Types and Concessions

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Extended Abstract:

Airport congestion toll has been widely discussed in the literature and factors, such as airline market structure, passenger types and concession activities, have all been incorporated in various analytical models. However, none of the studies has differentiated the congestion incurred in the terminals from the congestion incurred on the runways, despite of the fact that these two kinds of congestion have different features with terminal congestion being totally “atomistic” while runway congestion showing a certain degree of “internalization,” and hence different implications to the airlines and the airport. In particular, terminal congestion seems to be less of a concern to the airlines’ operations, but it will likely affect passenger behavior and airport concession activity to a large extent. On the other hand, runway congestion is more of an issue to the airlines but has less to do with airport concessions. In other words, airport concessions and passenger types are related more closely with terminal congestion than with runway congestion. Therefore, separating these two kinds of airport congestion may help clarify and deepen our understanding of the interactions between different factors in designing an optimal airport charge.

This paper develops a framework that integrates the two kinds of congestion by adopting a deterministic bottleneck model for the terminal to describe passengers’ behavior and a simpler static congestion model for the runway. The bottleneck model can capture features such as varying congestion over the time and travelers’ response to congestion tolls by adjusting departure time, but it only fits the cases where users of a congestible facility are all “atomistic” (such as cars on highways). Airport terminals face individual passengers who are by definition atomistic and won’t take into account other passengers when making decisions, so it appears to be a perfect context for the usage of the bottleneck model. This new modeling method enables the terminal dwell time to be elicited by individual passengers’ airport arrival behavior which is affected not only by the number of passengers but also by the passenger types.

In particular, we consider a congestible airport served by \( n \) identical airlines and focus on departing passengers. There are two types of passengers: business and leisure, with different values of time.
When passengers make air travel decisions, they take airfare, runway congestion cost and terminal cost into consideration. The pre-departure procedure at the terminal, such as check-in, security screening and passport control (if any), is collectively considered as a bottleneck. When passengers are lining in the queue for the pre-departure procedure, they incur queuing costs. When passengers finish pre-departure procedure before the scheduled gate closing time, they incur early schedule-delay costs. The terminal cost is the sum of queuing cost and early schedule-delay cost at the terminal. We assume that passengers minimize their individual terminal costs by choosing their terminal arrival time. The airport and airline behavior is modeled as a two-stage game: in the first stage, the airport chooses its charges to maximize social welfare. In the second stage, airlines simultaneously determine output levels to maximize their respective profits. Here, each airline may make separate decisions on the number of business passengers and the number of leisure passengers, implying that airlines can price discriminate between the two passenger types.

We find that different from the results obtained in the literature, uniform airfare does not yield the first-best outcome when terminal congestion is explicitly taken into account. This is because some passengers may prefer arriving at the airport far in advance to avoid long queues at check-in and security screening, while others may prefer arriving at the airport relatively late to avoid long airside dwell time before boarding. Intuitively, adding a passenger who arrives at the airport at a particular time may increase the queuing time for those arriving after her and the airside dwell time for those arriving before her by pushing their arrival times forward. As a result, different passengers cause different externalities on the others. Thus, the amount of terminal externality to be internalized varies across passenger types, although additional passenger leads to the same amount of congestion on runway regardless the passenger types. In particular, we find that business passengers are at first-best charged a higher fare than leisure passengers if and only if their relative schedule-delay cost is higher. The relative schedule-delay cost is defined as the relative cost of early schedule delay to time delay and is equivalent to the ratio of the unit early schedule delay cost to the unit time delay cost.

Furthermore, we identify circumstances under which passengers are, under a uniform airport charge scheme, under- or over-charged with respect to the terminal charge. Although the amount of externality passengers impose on others at the terminal differs across passenger types, since passengers cannot be discriminated for charges at terminal, as a result, a particular passenger may pay more, or less, than the uninternalized cost she imposes on the others.

Finally, although finishing pre-departure procedure too early raises cost to passengers, it increases passengers’ airside dwell time which may raise the demand for airside concession (non-aeronautical) goods or services. Thus, when concession surplus is added to the analysis, the airport may raise (rather than reduce) the airport charge in order to induce more business passengers who in turn will lengthen leisure passengers’ dwell time and hence increase their chance of purchasing concession goods.

Keywords: Airport Pricing, Terminal Congestion, Runway Congestion, Passenger Types, Terminal Concessions