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A roadmap toward airport demand and capacity management

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ABSTRACT

This paper synthesizes the major interventions available to manage airport demand and capacity, the analytical tools that may support the underlying policy, managerial and operational decisions, and guidelines for policy and practice obtained from recent research. The resulting insights fall into three broad categories. First, airport throughput exhibits significant variability, and airport capacity depends on the available infrastructure and operating procedures. Second, airport on-time performance is highly non-linear, and thus sensitive to variations in demand and capacity. Third, airport demand management involves a trade-off between mitigating congestion and maximizing capacity utilization, and scheduling mechanisms can support and enhance existing practices. The implications for the development and management of airport systems worldwide are discussed.

1. Introduction

1.1. Problem of demand and capacity management

Airports play a central role in urban development by connecting individuals, businesses and governments, and spurring indirect commercial activities. Over the past decades, airports have accommodated increasing numbers of operations to support regional and national growth and airline business development. Despite declines following 9/11 and during the economic downturn in 2008 and 2009, air traffic has grown significantly in the United States and Europe, and even more rapidly in Asia and Oceania and, more recently, in Africa and Latin America. At the same time, airport throughput is limited by the existing infrastructure and operational capabilities. At many of the world's busiest airports—and despite a number of capacity expansion projects (e.g., the construction of new runways)—demand for airport access has grown to often exceed airport capacity in many metropolitan areas. The impact of the resulting imbalances between demand and capacity depends on access policies (see Section 1.2). At airports with largely unconstrained access (e.g., the overwhelming majority of US airports), the result can be over-capacity scheduling and delays, with significant congestion costs—for instance, the nationwide impact of flight delays in the United States was estimated at over $30 billion in 2007 (Ball et al., 2010). At airports where access is restricted (e.g., most of the busiest European airports), the restrictions can result in demand losses and/or demand displacement (e.g., to less preferred times of the day or to other airports). At the opposite end, airline demand at less busy airports may fall well below available capacity, resulting in the under-utilization of infrastructure resources. For airports under development, this underscores the need for proactive management of demand and

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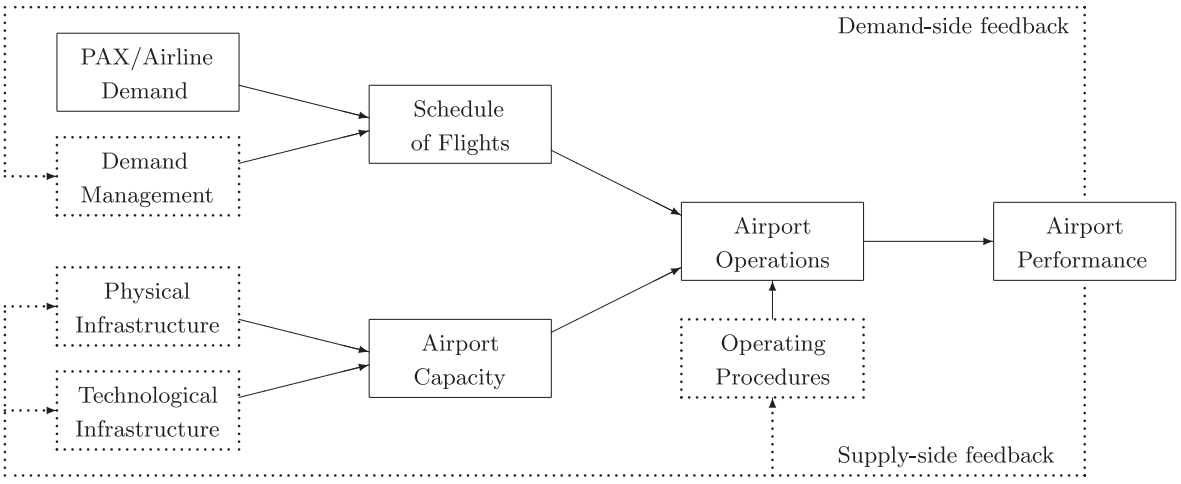

Fig. 1. Schematic representation of airport planning, management and operations (decisions are indicated in dashed lines).

capacity, ranging from long-term infrastructure planning to medium-term infrastructure management and short-term infrastructure operations.

This paper synthesizes the major operational, managerial and policy mechanisms available to manage airport demand and capacity, the analytical tools supporting the underlying decisions, and the implications for the development and management of airports. As indicated by Keeney (1973) in the context of the (existing) Mexico City airport, this requires consideration of multiple criteria, such as ensuring safety, maximizing throughput, minimizing capital expenditures and operations costs, promoting airline competition, mitigating air traffic congestion, and promoting environmental sustainability. These objectives can be aligned (e.g., mitigating congestion has a positive environmental impact), but may also give rise to some trade-offs (e.g., increasing throughput generally requires significant investments). Moreover, airport operations affect a number of stakeholders, including Civil Aviation Authorities, airport operators, commercial airlines and other aircraft operators, passengers, local communities, etc. Therefore, the management of airport demand and capacity creates complex decision-making challenges that require the identification of airport performance objectives and stakeholder incentives over the course of airport lifecycles (Neufville et al., 2013; Zografos et al., 2013).

Airport performance depends on three primary factors: (i) airport capacity, (ii) operations management, and (iii) flight scheduling. Demand and capacity management interventions can thus be classified into three categories. First, infrastructure expansion aims to increase potential capacity through the development of greenfield airports or the expansion of existing airports. Second, operational enhancements aim to improve the efficiency, reliability and sustainability of airport operations, given the available physical and technological infrastructure and fully complying with safety constraints. Third, demand management aims to modify the temporal and/or spatial characteristics of demand through access regulation that controls the number of peak-hour flights scheduled at the busiest airports, or through incentives to spur demand at off-peak hours or at underserved airports. Although interdependent, these decisions are typically made in sequence: airports first plan their capacity based on demand forecasts, then optimize air traffic handling procedures to minimize operating costs, and, last, may need to implement demand management schemes if capacity lies well below airline demand. Fig. 1 provides a schematic representation of these decisions and their impact on airport demand, capacity and, ultimately, performance.

The design and optimization of demand and capacity management interventions requires contributions from the fields of transportation economics, management, and operations. From an economic standpoint, an efficient scheme allocates scarce airport capacity to the users that assign the highest value to it, through quantity-based or price-based mechanisms. From a managerial standpoint, decision-making tools support the planning of airport capacity (a supply-side intervention) and the scheduling of flights (a demand-side intervention). From an operational standpoint, the characterization of airport capabilities makes it possible to predict and, where possible, improve performance. For comprehensive reviews of the underlying modeling advances in these different fields, we refer the reader to (Czerny et al., 2008; Zhang and Czerny, 2012; Zografos et al., 2013, 2016; Gillen et al., 2016). While the economic aspects of the problem have been the subjects of extensive research (some of which is reported in this volume), this paper focuses on the management and operations problems. Specifically, it describes a bottom-up approach that begins with the characterization of airport capacity, operating capabilities and demand patterns, and provides decision-making support for enhancing airport performance through infrastructure expansion, operational enhancements and demand management.

1.2. Overview of current practices

We briefly review the major differences observed worldwide in airport infrastructure, operating procedures and flight scheduling. The range of these practices provides guidelines to address demand and capacity management trade-offs.

First, the physical infrastructure of busy airports varies significantly by size and physical layout. For instance, most European airports exhibit simple layouts, with a single runway or 2–3 parallel runways. In contrast, many US airports have more than three