Airport pricing policies: airline conduct, price discrimination, dynamic congestion and network effects

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Summary

Air transport has been at the core of the economy and of the daily life for some decades now. Nowadays, aviation is an essential part of the economic activity: firms, households, tourism and trade rely, to a substantial and growing extent, on air transportation. For example, since 1980 the number of passengers transported by air has increased more than fourfold and, in 2012, airlines transported over 3 billion passengers (ATAG, 2014). A downside of this growth is that air transport delays now pose an acute problem on airports globally. For instance, Ball et al. (2010) estimate that the cost of US air transportation delay in 2007 was \$16.7 billions to passengers, \$8.3 billions to air carriers, and that it reduced the 2007 US GDP by \$4 billion. Not surprisingly, policies aimed at reducing airport congestion costs have gained increased attention from governments, policymakers and researchers.

The economic rationale behind a government intervention in this market is partly based on that delays are a consequence of the presence of negative externalities. In this market, the externality arises because there is a cost of traveling that is not borne by the passenger that travels, and a cost of scheduling a flight that is not borne by the airline that schedules the flight. An additional flight or passenger imposes additional travel time costs on other flights and passengers through interactions on the runway, in the air, in security screening areas, or gateways. This is normally referred as the congestion externality. Other negative externalities are also present in air transport markets: noise, air pollution and carbon emissions are main examples. Pigou (1920) and Knight (1924) already recognized the presence of congestion externalities in road traffic, and since then we know how this market failure leads to a sub-optimal outcome, where the free-market level of consumption (e.g. number of trips) is higher than socially optimal.

Solutions to address the increasing delays at airports have been intensively discussed in the literature. The main alternatives are capacity expansions, controlling the total flight volume through slot constraints and implementing optimal congestion pricing. The latter is the policy path that this thesis is concerned with. The objective of this thesis is to study airport pricing policies from a social welfare standpoint in the presence of congestion externalities and in the presence of market power exertion by airlines. That is, to study pricing policies that are concerned with eliminating the excessive delays, recognizing that airlines are not price takers, but large agents that possess the ability to affect prices and delays. This thesis, therefore, models the consumers' choice of traveling and the airlines' behavior to study efficient airport pricing policies.

This thesis emphasizes the role of the airlines' decisions in terms of fleet timing, which comprises a trade-off between queuing delays and schedule delays, in shaping the socially optimal pricing policies. It investigates the policy implications of adopting different assumptions on airline market conduct, such as the models of competition introduced by Cournot (1838), Bertrand (1883) and von Stackelberg (1934). Furthermore, it character-

izes the role of different pricing instruments in achieving the socially desirable outcome such as time-variant, time-invariant, per-flight and per-passenger airport charges.

Chapter 2 analyzes airport congestion pricing using Vickrey's (1969) bottleneck model of congestion at an airport dominated by a single airline. Unlike much of the previous literature, the chapter combines a dynamic model of congestion and a vertical multi-level model that explicitly considers the behavior of airlines and passengers. By focusing on the competition between a Stackelberg leader and a competitive fringe, the chapter establishes the relation between the degree of internalization of congestion in the untolled equilibrium and the demand substitution pattern between leader and fringe. This extends the results of previous analysis in static models of congestion, notably those of Brueckner and van Dender (2008), to a dynamic setting. An important conclusion of the chapter is that there are multiple pricing schemes that correct the congestion inefficiency, including schemes with and without time-dependent charges. These schemes are crucially affected by the degree of internalization in the untolled equilibrium. The dynamic nature of the model explains these results: the leader's response when facing an optimally priced competitive fringe is fully efficient in terms of the timing of the flights, but not in terms of the aggregate number of flights. Therefore, a time-invariant toll can induce the leader to behave efficiently. Yet, time-variant tolls charged to the leader do not cause a distortion in the timing of flights, so that also this type of charge is able to induce the welfare maximizing outcome.

The policy implications of the chapter are manifold. The analysis shows that a regulator concerned with pricing an airport that is well represented by the interaction between a dominant airline and a number of small competitors has a diverse set of charges that achieve the social optimum. The different pricing schemes differ in the degree of differentiation between leader and fringe and in the revenue collected. Consequently, the regulator can choose the pricing regime that suits better its objectives and possibly enhance the implementation feasibility. Chapter 2 shows that policy implications obtained from static models can be significantly different from the implications produced by dynamic models. Therefore, in airports where a dynamic model of congestion is more pertinent because, for example, the operational conditions for arrivals (or departures) follow the first-in first-out (FIFO) discipline, caution is required to transfer results and policy recommendations from static models. The FIFO discipline applies, for example, at airports that are not subject to slot constraints.

Chapter 3 extends the analysis of the previous chapter by considering simultaneous fleet scheduling by airlines. This chapter investigates the existence, uniqueness and properties of equilibrium in the Vickrey bottleneck model when each firm controls a sizable fraction of total traffic. Firms simultaneously choose departure schedules for their vehicle fleets and each firm internalizes the congestion cost that each of its vehicles imposes on other vehicles in its fleet. The chapter shows that when firms are homogeneous, a pure strategy Nash equilibrium (PSNE) may not exist and in the cases where it does exist, there are no travel delays. The implications of these results are straightforward. First, in the standard bottleneck model with users that control a single vehicle, a PSNE exists under relative general assumptions (see Lindsey, 2004). Thus, simple congestion-prone systems with firms that are large players, such as airlines, can exhibit fundamentally different dynamic behavior than with small (road) users. This, again, has important implications in terms

of the transferability of policy recommendations from static models. The chapter also demonstrates that when a PSNE exists, homogeneous firms may incur appreciably different costs even when the outcome is socially efficient. This implies that equity of access to a bottleneck can be an issue when firms control large shares of traffic at congestible facilities. Thus, a regulator concerned with equity may want to regulate the market even though the outcome in terms of timing of the vehicles is efficient.

The chapter finds that when firms differ in their desired arrival time, multiple PSNE may exist in which also no queuing occurs. However, the timing of departures may be inefficient in that departures may begin earlier or later than the social optimum. This result implies that even though there is no queuing, there are still negative externalities of scheduling and there is room for regulation in the market. Nevertheless, the chapter shows that a large share of the potential benefits from regulation are realized in equilibrium due to the internalization of self-imposed congestion by firms. This indicates that a pricing policy in this case would not bring large benefits and if the implementation costs are significant it may be that a *laisse-fairez* policy is socially optimal.

Chapter 4 concentrates on analyzing the internalization of self-imposed congestion under different assumptions on airlines conduct, namely under a Cournot and Bertrand differentiated oligopoly and a duopoly in which one firm is a Stackelberg leader. Under a Cournot oligopoly, carriers fully internalize the congestion that they imposed on themselves. However, under a Bertrand oligopoly carriers internalize less congestion than what they impose on themselves. The chapter finds that the degree of internalization under a Bertrand duopoly depends on demand-structure parameters, namely the degree of substitutability between the firms' products, and approaches zero as firms' products are closer substitutes. This has important implications: when Bertrand competition is pertinent, the welfare gains of congestion pricing are larger, the socially optimal charges are less differentiated, and the degree of self-financing of airport infrastructure is higher than under a Cournot oligopoly. Therefore, not only the efficiency gain from congestion pricing is enhanced, but arguably its implementation feasibility as well.

In addition, chapter 4 characterizes the unique role of per-passenger and per-flight charges in achieving the efficient outcome. An important conclusion is that both pricing instruments are needed for social welfare maximization, as congestion externalities need to be addressed through per-flight tolls and the market power inefficiency must be corrected with per-passenger subsidies. There are implications for second-best policies as well. As the two counteracting effects that need to be addressed (market power and congestion) are not merged in one pricing instrument, whenever it is optimal to give subsidies and these are not feasible, it is not necessarily the case that the second-best policy is to abstain from charging airlines. The analysis shows that there is large scope for implementing (second-best) congestion pricing when subsidies are not feasible and that its efficiency relative to the first-best is higher, the closer substitute airlines are, and the more firms participate in the market. The numerical analyses suggest that implementing congestion pricing as if airlines would not internalize any congestion may yield substantial benefits, importantly, in the presence of market power distortions.

Chapter 5 investigates airport pricing policies from a different, yet complementary, point of view. It studies under which conditions it is efficient to enforce a ban on price discrimination to airports, taking into account the different ownership forms of airports.

Summary

The analysis shows that input price discrimination by a private airport, i.e. setting different prices for different firms, can increase aggregate output and increase welfare. In a similar setting and in absence of congestion, aggregate output does not change and welfare is reduced when price discrimination is allowed. Therefore, the presence of negative consumption externalities enlarges the extent to which input price discrimination is desirable. The chapter also shows that allowing price discrimination by a public facility can improve social welfare and describes the conditions under which enforcing a ban on price discrimination is an efficient policy for both types of facilities. A main conclusion of the chapter is that there is a limited scope for the ban to improve social welfare in both cases. Therefore, an important policy guideline that follows from the analysis is that a broad ban on input price discrimination, such as the European wide ban enforced by the EU directive on airport charges, may need to be revised. The ownership form of airports, especially in Europe, has been gradually changing from fully public to private. For example, in 2010, 48% of all European air traffic was handled by a fully or partially private airport (ACI-Europe, 2010). Therefore the policy of banning price discrimination needs to be particularly reassessed in places where privatization of congestible facilities is increasing.

Chapter 6 studies socially optimal airport pricing policies from a long-run perspective. It investigates how airlines choose their route structure in a given network and compares it with the route structure configuration that maximizes social welfare. The main focus of the chapter is to examine whether the efficient network configuration can arise as an equilibrium when a regulator sets per-passenger and per-flight charges in the network. A main policy conclusion is that a regulator setting airport tolls concerned with correcting output inefficiencies may not achieve the efficient outcome in terms of route structure configuration. Thus, a regulator may benefit from using an additional instrument that is concerned with correcting the network configuration inefficiency directly. Another main policy implication from the analysis is that information such as marginal benefits and marginal costs is not always enough to design a regulatory scheme that can achieve the social optimum. This is because discrete changes in welfare due to discrete changes in route structure configurations need to be assessed. It is possible that in order to fully reap the long-run benefits from congestion pricing, the tolls should be designed for a different route structure configuration than the one that is observed. The numerical analyses show that, although the "wrong" network can arise if the regulator does not control the route structure choice of the airlines, the relative welfare losses of having this sub-optimal network configuration are limited. This is due to the fact that the difference, in terms of social welfare, between the welfare-maximizing network and the profit-maximizing network is limited when optimal pricing is in place. Therefore, even though a direct network regulation may be necessary, in addition to optimal pricing, to achieve the social optimum, the welfare losses of not doing so are likely to be limited.

In summary, and at the risk of generalizing, the main policy implications from this thesis can be summarized as follows. First, per-flight and per-passenger airport charges are complementary pricing instruments in achieving an efficient outcome from a social welfare standpoint. There is limited substitutability between those instruments and policies aimed at a containment of negative externalities while recognizing the presence of market power should take into account the unique role that each pricing instrument has

in achieving the different objectives. Second, in airports where the operational conditions for arrivals or departures follow the first-in first-out discipline, regulators may have a wide set of pricing policies that lead to equally efficient outcomes. This could arguably enhance the implementation feasibility of a socially optimal policy. Third, also in the cases where dynamic congestion models are more pertinent, the outcome of competition between firms may not exhibit congestion and still be inefficient because of schedule delay externalities. This means that regulation in terms of timing of flights in uncongested markets may be beneficial. In addition, even if the outcome is socially efficient, firms may perceive significantly different costs. A policy maker concerned with equity of users (firms and consumers) may want to intervene the market despite its efficiency. Fourth, the airlines' degree of internalization of self-imposed congestion and thus the extent to which congestion charges set by the airport can increase welfare depend crucially on the market structure and, particularly, on whether Cournot or Bertrand competition is more pertinent. Moreover, under Bertrand competition, the degree of substitutability between the airlines' products crucially determines the degree of internalization of self-imposed congestion. Finally, broad regulations on price discrimination that extend over numerous transport facilities with different congestion levels and ownership forms may be inefficient.