# Auctions as a Vehicle to Reduce Airport Delays and Achieve Value Capture

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Congestion at airports imposes large costs on airlines and their passengers. A key reason for congestion is that an airline schedules its flights without regard to the costs imposed on other airlines and their passengers. As a result, during some time intervals, airlines schedule more flights to and from an airport than that airport can accommodate and flights are delayed. This paper explores how a specific market-based proposal by the Federal Aviation Administration (FAA), which includes the use of auctions to determine the right to arrive or depart in a specific time interval at airports in the New York City area, might be used as part of a strategy to mitigate delays and congestion. By explaining the underlying economic theory and key arguments with minimal technical jargon, the paper allows those with little formal training in economics to understand the fundamental issues associated with the FAA's controversial proposal. Moreover, the basics of the proposed auction process, known as a combinatorial auction, and value capture are also explained. (JEL R41, R48, L93)

In rankings of on-time arrivals and departures for major airports, New York City area airports fare poorly. For 32 major airports during 2008, the on-time arrivals of Newark Liberty International Airport (Newark) ranked 32nd, LaGuardia Airport (LaGuardia) ranked 31st, and John F. Kennedy International Airport (Kennedy) ranked 29th.[1] Their on-time arrival percentages—Newark's 62 percent, LaGuardia's 63 percent, and Kennedy's 69 percent—revealed that fewer than seven of every ten flights arrived on time.[2] Thus, more than three of every ten flights arrived 15 or more minutes past their scheduled arrival time.

Many factors, such as weather and mechanical problems, determine an airport's on-time performance. This paper focuses on the delays and congestion associated with the scheduling of flight arrivals and departures. Generally speaking, an airline schedules its flights without regard to the costs it imposes on other airlines and their passengers. When airlines schedule more flights to and from an airport than that airport can accommodate, flights are delayed. These delays impose large costs on the airlines themselves and, ultimately, on passengers. With respect to New York City area airports, Levine (2009) cites an estimate that these airports are involved in three-quarters of congestion delay in the entire U.S. system. We explore

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[1]  Using on-time departure data provides a similar picture. For 2008 Kennedy ranked 26th, LaGuardia ranked 28th, and Newark ranked 31st. See "Airline On-Time Statistics" (www.bts.gov/xml/ontimesummarystatistics/src/index.xml).

[2]  These on-time arrival statistics likely understate the extent of the problem. Because a late arrival is one landing 15 minutes past its scheduled arrival time, airlines can increase their on-time percentages by increasing the scheduled flight time. See Whalen et al. (2007).

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how a specific market-based approach, the use of auctions to determine the right to arrive or depart in a specific interval of time, might be used as part of a strategy to mitigate delays and congestion.

The focus on specific time intervals reflects the fact that the demand for passenger travel varies throughout a day. It is this variability that increases the odds that the demand for takeoff and landing slots at certain times during the day will exceed an airport's capacity. Takeoff and landing fees that do not vary throughout the course of a day are simply too low to efficiently allocate the scarce good of the right to land or depart during some time intervals. Armed with this economic insight and eager to solve the obvious congestion problem, many economists have suggested using a market-based approach.[3]

On September 16, 2008, the Federal Aviation Administration (FAA) announced its intention to implement a market-based approach by auctioning a limited number of slots at Newark, LaGuardia, and Kennedy airports starting on January 12, 2009.[4] Ideally, the auctions would ensure that the slots would be purchased by airlines placing the highest value on those slots. In addition, the FAA stated that the proceeds from the auctions would be spent on New York City area projects to mitigate congestion and delay.[5] Consequently, in a cost-effective way, the FAA hoped to achieve its goals: reduce some congestion directly and immediately

and generate financing for additional projects to reduce congestion and delay in the future.

Despite the potential for the FAA's approach to alleviate delays, numerous parties voiced strong opposition against it—including the Air Transport Association of America (ATA), the Port Authority of New York and New Jersey (PANYNJ), and legislators.[6] In mid-December 2008 a three-judge panel of the U.S. Court of Appeals for the District of Columbia Circuit ruled that the slot auction could not be held until a federal court ruled on the objections raised by the ATA and the New York airport officials.[7] Effectively, the court decision shifted the question of whether to move forward with the auctions from the Bush administration to the Obama administration. Most recently, in spring 2009, the U.S. Department of Transportation announced the cancellation of the slot auctions.[8]

Despite the lack of immediate public-policy relevance, an examination of the FAA's proposal is still of much value because of the important economic issue that it addresses and the interesting economic and political arguments associated with it. Our primary goal here is to make the theory and the arguments, especially those relying on economics, accessible to those with little formal training in economics. We begin by identifying insights from economic theory that are relevant to dealing with congestion. Next, we summarize the FAA's proposal and then identify the key features of the proposed auction. With economic theory and the proposal as background, we then turn to the arguments for and against the FAA's proposal.

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[3] See Whalen et al. (2007) for a discussion of failed policies that have attempted to reduce delays at LaGuardia, Kennedy, O'Hare, and Washington's Reagan National Airport.

[4] The actual use of auctions in the context of airports would be novel; however, auctions have been used in other settings, such as airwaves and pollution rights. As discussed by Tietenberg (2000), the approach can be viewed as a property-rights approach. A market is created by defining a property right and then allowing the right to be traded. Many issues immediately arise, one of which is who is given the right initially. A government agency might hold the right initially and then auction it off or it might allocate the right based on some history of activity or some other way. Concerning greenhouse gas emissions, the initial allocation is a key component of a cap-and-trade program. As discussed in *The Economist* (2009), the possible use of auctions for reducing emissions in the United States is controversial.

[5] Morrison and Winston (2008) provide suggestive evidence supporting such spending. They found that $1 of FAA spending reduced the costs of delay to airport users by $2.13 and that this spending could generate even larger benefits if it were allocated toward airports with the greatest delays.

[6] The ATA, which represents the nation's largest airlines, filed a lawsuit to stop the auctions, arguing that the government lacked the legal authority to impose the auctions. The Port Authority of New York and New Jersey, which runs all three airports, supported the ATA. Senator Charles Schumer from New York characterized the proposed auctions as insanity and argued: "Auctions have never been tried and were hatched by a handful of ivory-tower types in the administration" (see Caterinicchia, 2008).

[7] See Holland (2008).

[8] See Bomkamp (2009).

## Figure 1

**The Efficient Quantity of Flights: Optimal Congestion**
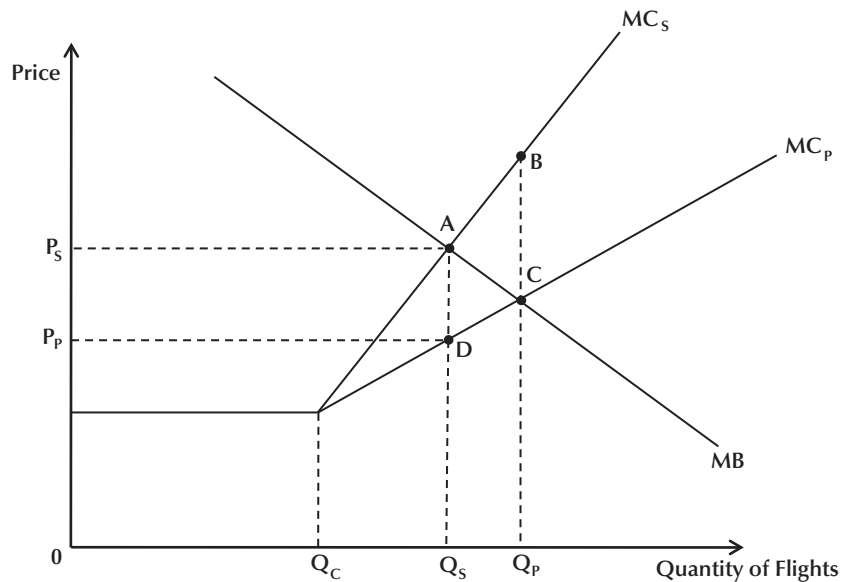


# CONGESTION AT AIRPORTS: SOME BASIC ECONOMIC PRINCIPLES

Congestion problems arise at airports when the flight activity scheduled by more than one airline for a period of time cannot be accommodated in that time frame and delays occur. Congestion at airports is an example of what economists term a "negative externality." A negative externality occurs when an individual consumer or firm making a decision does not have to pay the full cost of the decision.[9] As a result, some costs are forced on other consumers and firms. The shifting of costs onto others means that social costs (i.e., the private costs plus the costs forced on others) exceed the private costs. When the decisionmaker does not bear the full costs, then the decision-maker will engage in too much of the activity.

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[9] Congestion is unlikely to be a problem at an airport dominated by one airline. Any congestion from that airline will delay primarily its own flights and, thus, the costs are borne by that airline. The airline will consider the effect of scheduling an additional flight on the revenues and expenses of its other existing flights, as well as the revenues and expenses of the additional flight.

## Economic Efficiency and Optimal Congestion

For our illustration, we focus on the scheduling of flights by airlines.[10] When we use the term *scheduled*, we also assume *flown*. Thus, the costs and benefits identified below are for scheduled flights that occur. In Figure 1, the quantity of flights is on the horizontal axis, while a measure of the value (price) of a scheduled flight is on the vertical axis. Private marginal cost, $MC_P$, measures the cost of an additional flight. For a small number of flights, private marginal cost is drawn as a horizontal line indicating the same incremental cost of additional flights. Eventually, private marginal cost is positively sloped, suggesting that additional flights become increasingly costly. In other words, the costs borne by the scheduling airline increase after the number of flights reaches $Q_C$. Meanwhile, social marginal cost, $MC_S$, includes private marginal cost plus the cost forced on other airlines when a specific airline schedules an additional

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[10] See Cohen and Coughlin (2003) for a similar discussion from the perspective of consumers.

flight. These latter costs are congestion costs, which are simply the difference between social and private marginal cost. In Figure 1, for a small number of flights the social and private marginal cost curves coincide: This reflects an absence of congestion costs. As the number of flights increases beyond $Q_C$, however, congestion occurs and social marginal cost lies above private marginal cost.

Airlines schedule flights to maximize their profits. The marginal benefit curve, which ultimately hinges on consumer demand, reflects the benefits (i.e., revenues) that the airline generates from a flight. These additional benefits decline as the number of scheduled flights increases.[11] As a result, the number of scheduled flights in an unregulated, competitive market will be $Q_P$.[12]

From society's point of view, $Q_P$ is an excessive number of flights because at this quantity of flights social marginal cost exceeds marginal benefit. Ideally, $Q_S$ should be the number of scheduled flights because, for a quantity of flights less than $Q_S$, the marginal benefits for scheduling additional flights exceed marginal social cost. Beyond $Q_S$, marginal benefits are less than marginal social costs. Note that some congestion exists at $Q_S$, so the optimal level of congestion is not zero, but rather some positive amount. The issue for policymakers is how to reduce the number of flights from $Q_P$ to $Q_S$.[13]

One option is to allow no more than a given number of landings and departures in a specific period.[14] In Figure 1, this means reducing the quantity of flights to $Q_S$.[15] Quantity-based regulation would limit the number of flights to this level. An important issue involves deciding who

is allowed to use the scarce arrival and departure slots. This can be done by maintaining the existing flight shares of airlines before the reductions, but this hinders potential new entrants and might cause some airlines to retain slots that they value less than other airlines might value them. Also, because the slots are valuable, the use of this option means that the government generates none of the potential revenue. Securing such revenue is part of a process termed "value capture." Forgoing this revenue might make the financing of future airport expansions reliant on less-efficient options, such as other taxes. See the boxed insert for a detailed discussion of the revenue-raising technique of value capture.

To overcome the likely inefficiency of simply continuing the existing flight shares, two market-based measures of allocating slots have been proposed, one relying on a price-setting mechanism and the other on a quantity-setting mechanism. Both measures can yield identical results, but considerations, such as uncertainty involving demand or supply and the cost of implementation, might lead to the superiority of one measure.

A price-setting mechanism, known as "congestion pricing," varies landing fees by time of day. With this approach regulators would set prices for landings and takeoffs that would yield the efficient level of output at the airport. In light of the excess demand for arrival and departure slots at certain times of the day, the goal of congestion pricing is to shift some demand during the most congested periods of the day to times when capacity is readily available (i.e., periods of excess supply). Rather than have fees that do not vary over the course of a day, access fees would be higher during peak travel hours to induce airlines to shift some operations from the peak travel hours to nonpeak travel hours. In Figure 1, a congestion tax equal to AD (or the difference between $P_S$ and $P_P$) per flight would induce airlines to reduce scheduled flights from $Q_P$ to $Q_S$.

Auctions are another market-based mechanism to mitigate the adverse effects of congestion and

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[11] This is analogous to the fact that lower airline fares are associated with an increase in quantity demanded on the part of airline passengers.

[12] The welfare loss stemming from the excessive number of flights is the area ABC in Figure 1.

[13] Congestion *might* be reduced by increasing capacity via adding runways and improving the air traffic control system, but these approaches do not deal with the externality problem. See Cohen and Coughlin (2003) for an introduction to the economics of airport expansions. A counterintuitive proposal for dealing with congestion has been highlighted by Dubner (2009). Closing LaGuardia would free up air space and allow Newark and Kennedy to operate more efficiently and at a higher capacity.

[14] Safety considerations also affect the actual number of arrivals and departures that an airport can handle.

[15] A similar option mentioned in Whalen et al. (2007) is to allow the airlines to negotiate with each other to reach a solution. Such an option is likely flawed because the interests of potential competitors and consumers would not be adequately served.

## Figure 2

**Prices Versus Quantity Regulation: Marginal Benefit Uncertainty**
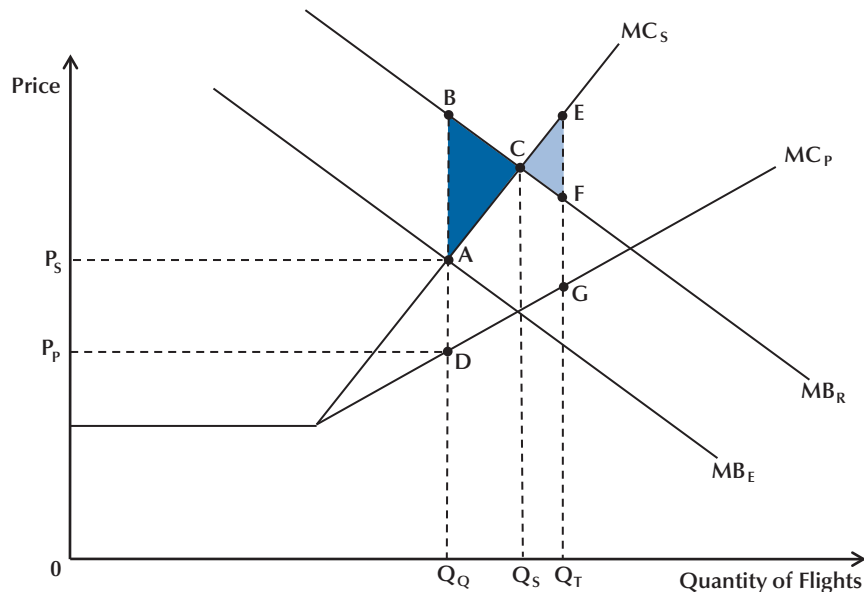


allocate scarce arrival and departure capacity efficiently. Auctions are viewed as a quantity-setting mechanism. Under this option, property rights to use the $Q_S$ slots are sold or leased to the highest bidders via an auction. The winning bidders would have the right to use the slots for some specific time period each day for the length of the contract or sell or lease the right in a secondary market.[16] With a second price auction, airlines would be induced to bid their true valuation for the slots, and the resulting payment would extract nearly the entire "surplus" from the airlines.[17] Thus, the auctions lead to the efficient outcome.[18]

### Adding Real-World Complexity

In the preceding example, the regulators were assumed to know the locations of the marginal benefit and marginal cost curves with certainty. A more realistic assumption is one of uncertainty, which allows for the regulators' expectations to differ from what actually occurs. This modification can cause the results of price regulation to differ from quantity regulation. Assume that the regulators are certain about the locations of the marginal cost curves but are uncertain about the location of the marginal benefit curve.[19] In Figure 2 this is represented by a realized marginal benefit ($MB_R$) curve that lies above the expected marginal benefit ($MB_E$) curve.[20]

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[16] Another feature of the property right, recommended by Whalen et al. (2007), is to include a cancellation priority. This would provide a way to allocate the slots when weather or some other factor temporarily reduced the number of arrivals and takeoffs that could be handled.

[17] In a second price auction, the highest bidder wins but pays a price equal to the second-highest bid.

[18] The economic roots of our discussion can be found in a classic paper by Weitzman (1974) that compares environmental regulation using a price (e.g., a tax on pollution emissions) with regulation using a quantity (e.g., emission standards).

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[19] This example can be characterized as illustrating regulatory cost uncertainty. Albeit confusing at first, the reasoning is straightforward. The benefits of regulation are the benefits of reducing congestion costs, while the costs of regulation are primarily the foregone travel benefits. Thus, in the example, the regulators are certain about the private and social (i.e., congestion) costs of airline flights, but are uncertain about the benefits of flights.

[20] See Adar and Griffin (1976) for a discussion of uncertainty with linear marginal benefit and cost functions.

# VALUE CAPTURE: ECONOMIC THEORY

Generally speaking, the use of most types of taxes to fund public projects creates some economic inefficiency. For example, a sales tax puts a wedge between the price paid by a buyer and the price received by a seller. Relative to a situation without a tax (i.e., the price is the same regardless of whether you are a buyer or a seller), imposing a tax tends to cause the price paid by buyers to increase and the price received by sellers to decrease. As a result, some mutually beneficial exchanges do not occur. Economists refer to the forgone benefits as a "deadweight loss."

This general result, however, does not hold when the supply curve is fixed at a specific quantity (that is, when supply is perfectly inelastic). Capping the number of slots would produce such a supply curve. In the accompanying figure, with the price of slots on the vertical axis ($P_{slot}$), and the quantity of slots ($Q_{slot}$) on the horizontal axis, the supply of slots is drawn as a vertical line at $Q^*$. In other words, suppose the airport (or the FAA) sets and controls the initial supply of "slots" by imposing operating limits and distributes these "slots" free of charge to the airlines. As discussed in the text, the determination of the socially ideal level of slots is far from easy. For the remainder of this discussion, we assume that $Q^*$ is the ideal level of slots. Meanwhile, the demand for slots is drawn with a negative slope, reflecting that the quantity demanded of this input for flights increases as its price declines. In other words, airlines will prefer to increase their slots as the price of slots decreases.

## Figure B1

**Taxing Perfectly Inelastically Supplied Slots**
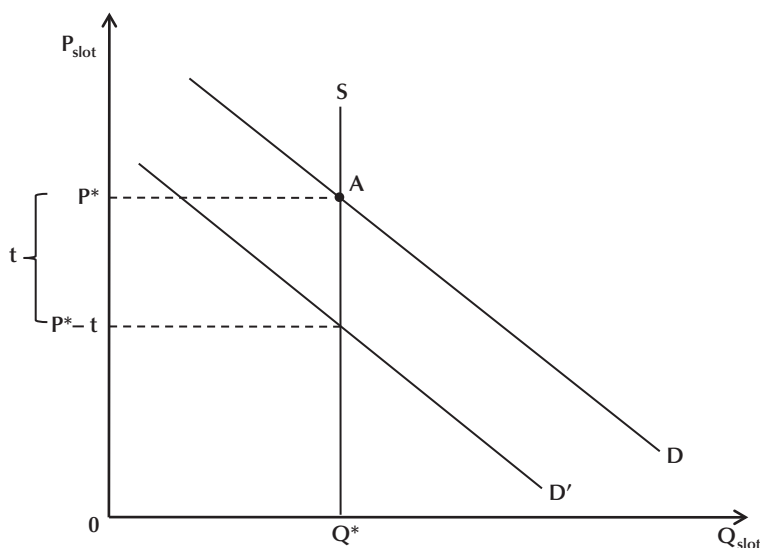
Because the supply of slots is perfectly inelastic, a tax (t) imposed on the owners of these slots will extract the maximum amount of tax revenue (or value) from the slot holders without distorting behavior of the "consumers" of slots.[1,2] In other words, there is no deadweight loss associated with this tax. The tax on slots would shift the demand curve downward, from D to D′, by the amount of the tax. The after-tax price received by sellers of slots would be (P* − t). Tax revenues would be the amount given by $t \times Q^*$.

To maximize revenue, the airport authorities would want to tax until tax revenues are slightly less than the area of the rectangle P*0Q*A. This scenario implies that the after-tax value of a slot is only slightly greater than zero, while virtually the entire surplus is captured by the taxing authority. The tax revenues could be used to finance airport operations, maintenance, and/or long-run airport improvements, and this approach would avoid the need for higher other distortionary taxes.

One might ask the following question: Instead of going through these steps to generate the highest possible amount of tax revenues by extracting the entire surplus, why not have the government sell these slots or hold a first-price auction?

There are two reasons. First, a practical problem arises in determining beforehand the position of the demand curve at different slot prices. In the typical case, the demand curve represents the airlines' reservation price. In the present case, it is not feasible to ask the airlines what their reservation price is for a given slot, which is the approach of a first-price auction, because of the incentive for airlines to understate their true valuation. A second-price auction is a plausible alternative because it is known to induce participants to bid their true valuation. In other words, the second-price auction organized by the government would be expected to extract the same amount of revenue from the airlines as a value capture tax on the slot holders in the amount of P*. So a second-price auction can be used as an equally effective (and efficient) method of value capture.

Second, to auction the slots, the government must rescind operating rights and possibly compensate the current occupants of the slots. We have shown that the government can generate the same revenues from a second-price auction as from a value capture tax. However, due to political pressures, the government likely would somehow need to compensate airlines currently holding the slots after reselling them at auction. As a result, net of these compensation costs, the government may actually end up with less revenue if it auctions slots than if it taxes current slot holders. Thus, from a political perspective, a value capture tax on the current slot holders may be a better approach to raising revenues than an auction, although the value capture tax may not solve the congestion problem in the same way as an auction. But, if the government were to reset the maximum numbers of flights and take back only some of the existing slots and impose a value capture tax on the remaining slots, this could be at least as effective as auctioning all of the slots in addressing congestion. It may even raise more revenues than an auction because fewer flights would have their slots confiscated and in turn, there would be less need for compensation.

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[1]  See Cohen and Coughlin (2005) for an exposition of the optimal taxation of land, which they assume is also perfectly inelastically supplied.

[2]  Similar to landing slot taxation, Tietenberg (2000) discusses the evolution of the current tradable discharge permits system in the United States. He notes that initially ozone depletion permits were given to pollution-generating firms and, later, these firms were taxed by the federal government because of the rents generated from the trading of these permits and the desire by Congress to generate revenues.

The regulators make their decision based on expectations, so they would impose a tax of AD per flight if regulating by price and a maximum number of flights of $Q_Q$ if regulating by quantity. Given a tax of AD per flight, the number of scheduled flights would be $Q_T$. The underlying reasoning is as follows: From the perspective of airlines, the tax of AD causes a parallel upward shift of their costs. This line, which is not drawn, is the private marginal cost curve plus the tax of AD. The intersection of this line with the realized marginal benefit determines the quantity of scheduled flights, which as stated previously is $Q_T$. Note that in Figure 2 the length of AD must equal FG. In this case, the quantity of flights would exceed the efficient quantity, $Q_S$, which is determined by the intersection of the social marginal cost curve and the realized marginal benefit curve. On the other hand, regulation by quantity would lead to too few flights because $Q_Q$ would be less than $Q_S$. Thus, neither form of regulation is efficient.

The welfare loss, measured as the deviation from economic efficiency, associated with price regulation is represented by the area of triangle CEF, while the welfare loss associated with quantity regulation is represented by the area of triangle ABC.[21] The preferred regulatory instrument is the one yielding the smaller welfare loss. As drawn in Figure 2, the area of triangle CEF is smaller than the area of triangle ABC, so price regulation is preferred to quantity regulation. However, we could have drawn Figure 2 so that quantity regulation is preferred to price regulation. Assuming straight lines, the flatter the slope of the realized marginal benefit curve relative to the slope of the social marginal cost curve, the more likely quantity regulation will become the preferred approach.[22]

The preceding example is focused on uncertainty involving the marginal benefit curve. What happens when the uncertainty is restricted to

social marginal costs? The answer is that price regulation and quantity regulation generate identical results—regardless of the slopes of the curves.[23]

The preceding discussion ignores the possibility that congestion at an airport depends on congestion at other airports. Two types of interdependencies—substitutability and complementarity—exist. In the first case, nearby airports compete with each other for passengers and cargo, so that increased traffic at one airport might reduce the traffic at a nearby airport. On the other hand, due to the network character of the air transportation system, airports also provide complementary services because a takeoff from one airport requires a landing at another airport. Thus, the increased use of runway slots at one airport tends to increase the demand for runway slots at other airports.

Czerny (2006) focuses on demand complementarity and compares the welfare effects of quantity regulation via slot constraints with price regulation via congestion pricing. His key conclusion is that the demand-related features of the airline industry increase the attractiveness of using slot constraints relative to congestion pricing. With congestion pricing airport usage is uncertain, and demand complementarity causes this demand uncertainty to propagate from one airport to another. Slot constraints can eliminate this propagation and can prevent the excessive use of runways and, thus, generate a preferred solution.

In contrast to Czerny (2006), Brueckner (2009) ignores both demand uncertainty and network externalities. He focuses on one airport served by more than one airline and allows the number of flights to differ across airlines. In his model, an individual airline accounts for the congestion costs that it imposes on itself (i.e., the airline internalizes congestion). He explores two price-based regimes and two quantity-based regimes.

Under a price-based regime, the airport authority announces a charge per flight for airlines to use a congested airport. The airlines then decide

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[21] The welfare loss associated with price regulation can be viewed in the following way: For each flight in excess of $Q_S$, marginal costs exceed marginal benefits. The triangle CEF measures the net total cost of these excessive flights. For quantity regulation, too few flights are scheduled because at $Q_Q$ marginal benefits exceed marginal costs. The triangle ABC measures the net total benefits that are forgone by not having $Q_S$ flights.

[22] This general result is not altered when the realized marginal cost curve lies to the right of the expected marginal cost curve.

[23] An assumption underlying the preceding analysis is that the uncertain benefit and costs functions are independent. Assuming a positive (negative) correlation of benefits and costs, Stavins (1996) finds that regulation by quantity (price) is likely preferred to regulation by price (quantity).

the number of flights. Two approaches are possible for the setting of prices. One approach entails charges that can differ across airlines, while the second approach entails an identical charge for each flight regardless of the airline. Under the first approach, assuming slot charges are set correctly, it is possible to produce the social optimum. Prices must vary across airlines because of the combination of different sizes of airlines with the fact that an airline takes into consideration the congestion it imposes on itself. Moreover, assuming two carriers, the larger carrier pays a lower congestion charge than the smaller carrier.[24]

Turning to the quantity-based regimes, the airport authority must begin by announcing a fixed volume of flights. The fixed (i.e., socially optimal) number of slots can be allocated either by (i) distributing the slots free of charge and allowing carriers to make adjustments through trading or (ii) auctioning the slots. Regardless of the allocation mechanism, the quantity-based regimes can produce a socially optimal result. This result is an illustration of the Coase (1960) theorem. When trade in an externality is possible and no (or sufficiently low) transaction costs exist, then an efficient outcome will occur regardless of the initial allocation of property rights.[25]

In sum, the scarcity associated with slot capacity can be addressed by having airplanes and travelers wait, politically deciding winners and losers, or by pricing the scarcity via a market mechanism. Economists tend to prefer the third option because of its efficiency properties. Relative to government decisions, the market mechanism allows for a speedier response to market changes. Moreover, the results based on economic theory

applied to airport usage provide a justification for using quantity regulation for runway usage. We now turn to the details of the FAA's plan and then the objections that have been raised.

## DETAILS OF THE FAA'S CONGESTION MANAGEMENT PLAN

On October 18, 2008, the FAA published its final rules concerning congestion management for LaGuardia, Kennedy, and Newark airports.[26] The FAA identified two primary methods to alleviate congestion. First, the current cap of 81 on the number of hourly takeoff and landing slot operations available at Kennedy and Newark airports during peak hours was extended and the number of peak hourly slot operations allowed at LaGuardia was reduced from 75 to 71.[27,28] Second, five consecutive annual slot auctions for a small number of slots at each airport (approximately 2 percent per year) would occur so that, in the face of the hourly caps on arrivals/departures, individual air carriers could attempt to increase their slot holdings through competitive bidding.[29] The funds collected from the slot auctions would be used to further mitigate congestion in the New York City area.[30]

The reduction in the total number of slots available at LaGuardia would have required a slot reallocation among operating airlines. According to its final rule, the FAA would have determined the structure of this reallocation. Viewing the slot reallocation at LaGuardia as integral for congestion management, the FAA would have

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[24] This result occurs because the larger carrier (i.e., the one with more flights) internalizes more of the congestion damage from its operation of an additional flight than does the smaller carrier. In this case, the common charge will penalize the larger (smaller) carrier too much (little) for the congestion it causes, resulting in the flight volume for the larger (smaller) carrier being too small (large).

[25] Transaction costs as well as strategic behavior can prevent the parties involved from reaching an agreement that is efficient. In addition, there are other considerations that could produce a preference for one allocation method over the other. For those airlines allocated slots free of charge, the receipt of such a valuable asset free of charge would be especially attractive. On the other hand, the airport authority would be forgoing revenue that could be used to improve the airport and the air transportation system.

[26] The final rules can be found at www.fly.faa.gov/ecvrs/circulars/ FR_JFK_and_EWR_final_rule_101008.pdf and www.fly.faa.gov/ecvrs/circulars/FR_LGA_Final_Rule_101008.pdf.

[27] The caps at Kennedy and Newark were originally imposed in the first half of 2008. Operational caps at all three airports are in effect from 6 a.m. until 9:59 p.m. each day.

[28] The FAA estimated that the new operational cap at LaGuardia would improve flight delays there by 41 percent. See page 60574 of the final rule for La Guardia (*Federal Register*, 2008b).

[29] A "slot," as defined by the FAA, is the right to land or depart during a 30-minute window.

[30] The FAA estimated the amount of net benefit from the LaGuardia slot auction would be $65.4 million. See page 60595 of the final rule for LaGuardia (*Federal Register*, 2008b).

required the same structured slot reallocation at Kennedy and Newark airports as well.

The terms of the slot reallocations were as follows: The FAA planned to grandfather 85 percent of total slots to existing slot holders, permanently retire 5 percent, and award the last 10 percent in increments over 5 consecutive years to the winners of annual slot auctions. The FAA would have allowed each air carrier to choose half of the 15 percent of current slots they were to surrender. The FAA would have decided the remainder to ensure that slots from every peak hour of the day were available both for permanent retirement and annual auction. In exchange for the terms of the slot reallocations, the FAA would have granted to each airline 10-year slot lease rights to all slots in its new allocation.[31]

Though the FAA intended to hold only one slot auction per year, it recognized that increased competition coupled with the operational caps might leave some airlines with fewer slots than desired after the first slot auction had taken place.[32,33] Therefore, a secondary market by which air carriers could buy and sell slots among themselves, subject to FAA oversight, was to be encouraged after the first slot auction was completed. Secondary market operations were to be allowed not only for slots won via the auction process but for all slots.[34,35]

The FAA's intention was that the secondary market for slots would grow and be sufficient to ensure an efficient allocation of slots long after the current congestion management rule expired in 2019. In other words, each slot would be obtained by the air carrier that valued it most. For some, maximizing a slot's potential would have meant using larger planes to transport more passengers at a given time. For others, it would have meant subleasing the slot if the gains from the sublease would have been greater than the marginal benefit from using it for their own business operations. In both scenarios, congestion would have been mitigated and travelers would have benefitted.

## DETAILS OF THE DESIGN OF THE FIRST FAA SLOT AUCTION

According to the final rules, the FAA's first slot auction would have offered the lease rights to at least 24 takeoff and landing slots at LaGuardia and approximately 18 slots each at Kennedy and Newark.[36,37] While these slot auctions were considered by the FAA to be integral to their long-term congestion management plans, the overall design of the slot auctions was a critical factor for success.

The design of any successful commercial auction must incorporate the following three features: (i) Its format must be well suited to the characteristics of the goods being auctioned; (ii) it must allow winners to be determined both quickly and fairly; and (iii) it must generate final prices that reflect a good's true economic value. We will now examine how the FAA's proposed slot auction design addressed these concerns.

### Combinatorial Auctions

That an even number of slots at each airport would have been auctioned is not by chance.[38]

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[31] Though some disagree, the FAA states that up to this point no carrier has held a proprietary right to any slot, and that they have held the right to withdraw slots from carriers at any time. See page 60574 of the final rule for LaGuardia (*Federal Register*, 2008b).

[32] As noted earlier, the FAA would have held five annual slot auctions. This is the number of years it deemed sufficient for firmly establishing slot prices given its decision to hold only one auction per year.

[33] It is worth noting that, in some cases, the first auction may have actually left some airlines with more slots than desired given the newly established market values associated with them.

[34] The FAA would also have allowed any air carrier to present slots for auction during any one of the five official slot auctions. The airline could have set a minimum price for each slot and retained all auction proceeds.

[35] The FAA planned to provide ongoing support for this secondary market. It would have allowed air carriers to post available and desired slot subleases on its website, and it would have made slot transactions transparent by posting their values after a sale. It would also have monitored the secondary market for any anticompetitive behavior. Each airline would have retained all monetary gains from these transactions.

[36] See page 60547 of the FAA's final rule for Kennedy and Newark (*Federal Register*, 2008a).

[37] The four subsequent auctions were to offer at least 22 slots at LaGuardia and at least 18 at Kennedy and Newark.

[38] That the overall number of slots to be auctioned was small was also not by chance. The forced reallocation of a relatively small number of flights was also designed to cause as little disturbance as possible to overall airport/airline operations.

Takeoff and landing slots are seen as complementary goods by most would-be auction participants. Understandably, in most circumstances an airline would want to own the right to a takeoff slot if and only if it also had the right to a subsequent landing slot at that same airport (i.e., it needs the ability to conduct a round trip). Therefore, if bidders could bid for multiple slots, they would be more likely to express their true valuation for them—as some slots would be valued more as one of a pair. Consequently, the FAA had determined that the first slot auction would have been conducted as a combinatorial auction where participants may bid on combinations of slots rather than being restricted to bidding for single slots only.[39]

Had the auction been designed as strictly for single items, air carriers likely would have incorporated into their bidding strategy the possibility of a worse situation should they win only one slot when a pair was needed.[40] One can easily see how this could lead to distorted bidding for slots to hedge against that outcome. Moreover, a distorted valuation of slots in the primary market would likely lead to price distortion, and therefore inefficiencies, in the larger secondary slot market as well—an outcome the FAA wanted to avoid.

Combinatorial auctions are not without their drawbacks, however. While theory has shown this auction type as the best way of auctioning complementary goods, real-world combinatorial auctions are rare. Even with modern computing, determining the winner of a combinatorial auction within a realistic amount of time can be difficult. As we will see, the mathematics underlying combinations is the culprit.

Combinatorial auctions are desirable specifically because participants may fully express their preferences for any desired combination of goods, but so too are they problematic for the same reason. For any $m$ items available in a combinatorial auction, there are $2^m-1$ possible non-empty bidding combinations. As one can imagine, offering all but a small number of items for auction would lead to extreme difficulty for the seller in evalu-

ating each bidding combination.[41] For example, the 24 slots offered in the first LaGuardia slot auction would have theoretically allowed for 16.8 million subsets of bids per bidder to be placed and, thus, to be evaluated. Even using today's computers the evaluation of 16.8 million subsets of bids would prove extremely time-consuming. Finding the solution for a combinatorial auction in which $2^m-1$ bids may be submitted is known, in computational parlance, as an exponential time problem.[42] Given the FAA's desire to determine winners within 2 days of the auction's end, allowing bidders to submit 16.8 million sets of bids would have, in fact, made winner determination impossible.[43]

For a real-world combinatorial auction, this winner determination problem requires the auction to be designed such that a trade-off between theoretical winner optimization and time is made. To do this, restrictions on bidding must be in place. One approach is to require that bids be made via a particular bidding language. Another is to set a limit on the number of bids allowed. The FAA would have done both.[44]

A "bidding language" is a computer-friendly language that allows bidders to more succinctly (computationally speaking) represent their desired combinations of items. Slot auction participants would have likely used a computer program into which bidders would have input their slot preferences. That program would have then translated those preferences into the predetermined bidding language. As such, all bids would have been represented in a way that a computer algorithm could have more easily selected the winning combination.

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[39] The auction would also have been sealed-bid and single round.

[40] In auction theory, this is known as the exposure problem.

[41] Likewise, a bidder can be overwhelmed by the number of bids he may submit and, therefore, be less likely to participate.

[42] Exponential time problems where $m$ is sufficiently large are contained in a class of mathematical problems formally defined as NP-complete. For a broader discussion of the limitations of modern computers with respect to NP-complete problems, see Aaronson (2008).

[43] See slide 58 of the "2009 New York Slot Auctions Bidders Seminar" (FAA, 2008b).

[44] For an excellent discussion of the real-world complexities of combinatorial auctions, including other approaches to the winner determination problem, see Cramton et al. (2006).

## Figure 3

**Five Bidders for Two Slots**

- $b_1$ {A} $= 28$ ⟵ Winners
- $b_2$ {B} $= 20$ ⟵
- $b_3$ {AB} $= 32$    Vickrey
- $b_4$ {A} $= 14$    Prices:
  $p_1 = 14$
- $b_5$ {B} $= 12$    $p_2 = 12$

To further increase efficiency, the FAA planned to restrict the maximum number of allowable bids to 2,000 per auction participant. While 2,000 is a small fraction of the theoretically possible 16.8 million, the FAA had determined that this number of bids would amply allow each carrier to express all preferences and, therefore, would not have compromised the fairness of the results.[45] Once all bids were received, the winners of each slot auction were to be identified by determining the collection of bids that maximized total revenue to the FAA subject to the constraints that no participant could win more than one combination of slots per airport and that no slot could be awarded more than once.[46]

It is reasonable to assume that, when notified, winners would be expected to remit payment equal to that of their winning bid. However, for the slot auctions, this would not have necessarily been the case. To deter bidding distortions, the FAA would have required winners to make a final payment consistent only with the bids of their strongest competitors.[47] This so-called bidder-

optimal core pricing strategy is similar, in auction theory, to a Vickrey second-price auction where the winner of a single good pays the price of the second-highest bid for that good.[48] However, given that the goods in the FAA slot auction could have been bid for in multiple combinations, in some cases the Vickrey price may have been too low.

### Determining Bidder-Optimal Core Prices

The following figures will demonstrate how, in the case of multiple bidding, final bidder-optimal core prices were to be determined.[49] Figure 3 shows the bids of five bidders ($b_1$, $b_2$, $b_3$, $b_4$, and $b_5$) competing for the lease rights to two slots (A and B). Subject to the constraints that no slot may be awarded more than once and that total revenue should be maximized, bidders 1 and 2 are declared the winners with a total bid of 48 for the two slots.

The Vickrey price for slot A is 14 while the Vickrey price for slot B is 12. However, bidder 3's bid of 32 for both A and B together, while still smaller than the total for the winning bids, exceeds the 26 that would be realized if winners were made to pay individual second prices. Therefore, in terms of a second-price pricing strategy, the seller will require a payment of at least 32 before awarding slots A and B. This is because the price of 32 for the joint A and B slots is the second-highest price compared with the price bidders 1 and 2 would bid if bidders 1 and 2 were to bid jointly on slots A and B.

Figure 4 identifies the competitive pricing core based on the five original bids. This competitive core area represents all prices between the revenue maximizing outcome of 48 and the next-best bid of 32. The competitive pricing core consists of all feasible combinations of prices that yield an efficient allocation of the two slots. In the present case, efficiency is directly related to the willingness to pay by the bidders. Ultimately,

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[45] Interestingly, this bid limitation may have actually *increased* auction participation by carriers as the total number of possible bids is more manageable even though some may argue that it is theoretically limiting.

[46] See Amendment 1 of the auction procedures (FAA, 2008a).

[47] Should a tie have occurred, it would have been randomly broken and the declared winner would have paid the full amount of his or her bid. Also, should only one carrier have bid for a particular slot, the competitive price for that slot would have been a nominal reserve price predetermined by the FAA.

[48] The following discussion relies on core theory. The core can be viewed as the set of feasible allocations that cannot be improved upon by trades within a subset of the economy's consumers. See Telser (1994).

[49] The figures, with some modifications, are from slides 25 through 29 of the auction bidders' seminar (see FAA, 2008b).

## Figure 4

**The Competitive Pricing Core**
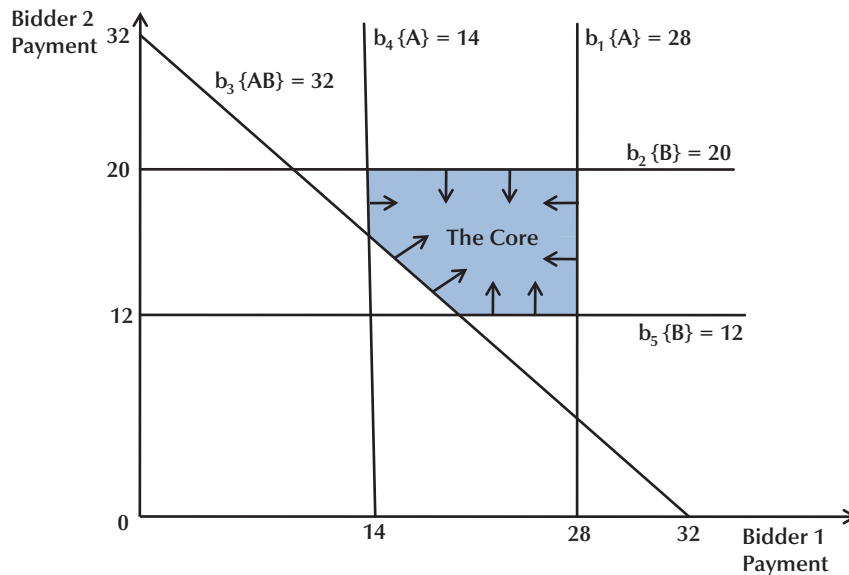


their willingness to pay ensures that the final prices reflect the economic value of the slots.

Given that bidders 1 and 2 are the winners based on their willingness to pay for the slots, the competitive pricing core consists of all feasible combinations of prices that yield at least 32. Because bidder 1 is willing to pay up to 28 for slot A, then any price above 28 is not feasible for bidder 1. In addition, bidder 1 must pay at least 14 because bidder 4 was willing to pay 14. Thus, the portions of the graph to the right of the vertical line at 28 and to the left of the vertical line at 14 are eliminated. Similarly, any price above 20 and below 12 is not feasible for bidder 2, which eliminates the portions of the graph above the horizontal line at 20 and below the horizontal line at 12. Finally, the competitive pricing core requires that the winning bidders jointly pay at least 32. The diagonal line provides the fifth and final side of the competitive pricing core.

To identify the final price each winning bidder may pay, the seller will reduce both bidder 1 and 2's bids subject to the constraint that jointly they must pay at least 32. This range of bidder

payments is identified in Figure 5 as the portion of the diagonal line (i.e., the border of the competitive pricing core) labeled the bidder-optimal core. The bidder-optimal core is all points of intersection between bidder 3's bid of 32 and bidder 1 and 2's possible final individual payments. However, given that there is no unique bidder-optimal core solution, how does the seller settle on individual final prices that are fair to both bidder 1 and bidder 2?

The seller chooses the bidder-optimal core price closest to the total Vickrey price of 26. As seen in Figure 6, this is the point on the graph representing the shortest distance between the Vickrey prices and the bidder-optimal core. According to Figure 6, bidder 1 would pay a final price of 17 while bidder 2 would pay a final price of 15.

Our elementary discussion suggests that the use of a combinatorial auction is far from straightforward. One of the many issues for policymakers is whether the likely benefits of such an auction in terms of economic efficiency and revenues for congestion-related projects outweigh its likely
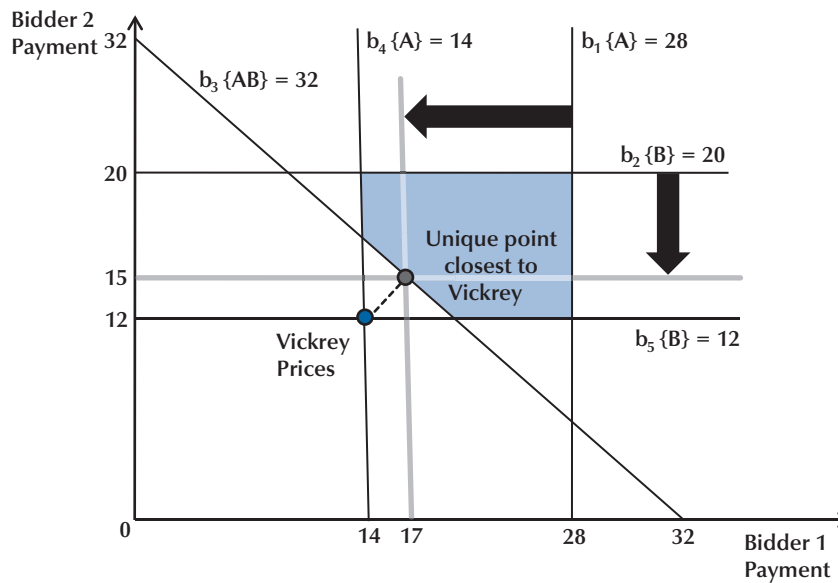
## Figure 5

**Bidder-Optimal Core Prices**
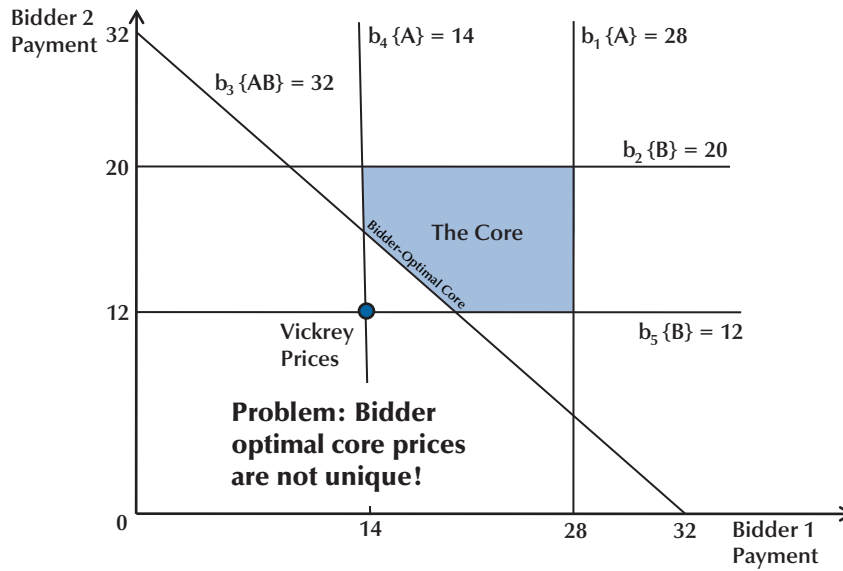


## Figure 6

**Winning Bids**

costs. We now turn our attention to additional issues raised by the FAA's proposal.

## A DISCUSSION OF ISSUES CONCERNING THE PROPOSAL

Numerous issues exist with using any market-based mechanism to deal with congestion. Our discussion is focused on economic issues, so we do not examine whether the FAA has the legal authority for its proposed rule.[50] Many objections highlight the harm that would be done to some group. Given that the implementation of any market-based option would cause some prices and airline transportation services to change, it is reasonable to expect harm for some groups. Some concerns stress the harm that would result if the auction plan were not implemented properly, while others stress the harm that some would bear even with proper plan implementation because they perceive certain features of the plan as unnecessary and counterproductive.

To date, auctions and congestion pricing have not been implemented on a broad scale at any U.S. airport. Many worry that prior experience with auctions and congestion pricing in other situations is not especially useful because of the uniqueness and complexity of the airline industry and its networks. Given the fragile financial situations of many airlines, the implementation of an ill-designed scheme could be harmful to travelers, airlines, and other stakeholders, such as the New York City region. One specific area of concern for such harm relates to the fact that both the airlines and the Port Authority have much debt and other financing tied to service levels.[51] Changes

to the service levels could lead to economic trauma.[52]

The preceding discussion leads naturally to the fact that the implementation of a congestion pricing or auction mechanism would entail transition costs. Obviously, the extent of these costs depends on the actual mechanism selected. The new situation could have a major impact on scheduling practices and require new investment to manage the new mechanism. Nonetheless, it is expected that these costs would prove minor and be offset over time by the gains in economic efficiency.

Given that the decision to use auctions is a political as well as an economic decision, the following question immediately comes to mind: Would there be so many exemptions to deal with these concerns that the use of an auction would do little to increase economic efficiency? Increased exemptions means higher prices for those not receiving exemptions and quite possibly those travelers would see few benefits in the form of operational efficiency or overall system performance.

The existing system does not generate an efficient use of resources and, as a result, there is overuse and excessive costs during peak hours. While the partial elimination of service is a possibility, air carriers have other possibilities that might be viable, such as flying at different (non-peak) times and using other airports, such as reliever airports for some flights.[53] A key point involving auctions is that the market mechanism provides incentives to use existing resources more efficiently.

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[50] Many ideas in this section were identified by Working Group 2 in *New York Aviation Rulemaking Committee Report*, December 13, 2007. Also, for a more detailed discussion of institutional issues related to slot auctions, see Levine (2009).

[51] A related issue concerns the "harm" for certain travelers. Without question, the use of auction pricing would cause some price changes and service changes. The monetary cost to travelers during the peak hours in the New York City area would likely rise and reduce general aviation access at those times; however, the nonmonetary costs of delays and congestion should decline. Some travelers would likely be harmed by higher airfares and reduced flight options, particularly those flying to small communities. Mid-size markets might also lose service. These markets demand high-frequency service that is provided by regional jets. Without exemptions from

congestion fees or auction prices, service to some or all of these communities would be reduced. But Whalen et al. (2007) stress that the elimination of what are termed "carve-outs" for corporate jets and general aviation users is a key aspect of their auction proposal.

[52] A poorly implemented plan could damage the industry. In a comment on the proposal to auction slots at LaGuardia Airport, the Federal Trade Commission (2008) specifically highlighted auctions involving electricity markets in California as a fundamental factor in the market meltdown. The issue is the likelihood of a poorly designed and implemented plan. This is possible; however, if done well, then the reduction of congestion costs should increase system reliability and provide savings related to time costs for consumers.

[53] In the present case, PANYNJ has purchased a lease for Stewart Airport (in New Windsor, New York, 60 miles north of New York City) as a reliever airport.

While auctions focus on the efficient use of slots, the allocation of slots also has important implications for the use of gates, hangars, and other physical assets. An airline that loses slots might incur losses due to declines in value on these other assets. Moreover, there is no clear mechanism whereby the winners of the slots can acquire access to these other complementary assets controlled by the losers. A longer-run possibility is that an airline might be less willing to make or support infrastructure investments in the future. With the advent of auctions and congestion pricing, the New York market is likely to be viewed as riskier and thus investment by airlines might be deterred. This complexity might be difficult to resolve without a higher governmental authority; yet, there would be incentives to reach mutually beneficial agreements. A secondary market for these other assets would likely resolve some of these concerns.[54,55]

Another set of concerns revolves around the fact that the U.S. airline industry operates in an international environment and is subject to international rules. For example, international routes are heavily dependent on connecting flights for domestic passengers, so anything that affects the connecting flights (times, frequencies, and so on) might make the related international flight unprofitable.[56]

A second international-related concern is whether foreign carriers would also be subject to congestion pricing or auctions. On efficiency grounds, all carriers should be subject to the same rules. As suggested previously in the context of an exemption granted to a specific U.S. carrier, any exemption of foreign carriers would put U.S. carriers at a disadvantage.[57]

Lastly, auction and congestion pricing schemes might violate U.S. bilateral and multilateral agreements, such as the U.S.–European Union Open Skies Agreement, because such charges are not cost based. The charges might be viewed as exceeding the full cost of providing the relevant air traffic control or airport services. From an economist's view, congestion is a true cost. Thus, from a theoretical perspective of an economist the schemes might not violate the law, but that does not mean the courts would agree.

So far, most discussion in this section has focused on winners and losers. In their comment on the proposal regarding LaGuardia, the ATA and their consultant argued for modifying the proposal in a way they felt would remove both complexity and uncertainty while retaining the benefits.[58] They argued that the proposed rule for LaGuardia could be separated into two distinct components, a cap of takeoffs and landings and an allocation of the slot rights. Recall from our earlier discussion that assuming certain conditions, it was possible an efficient outcome could result regardless of the initial distribution of slot rights. With an active secondary market, it would be possible that trading of slot rights would lead to an efficient outcome.

While the FAA's imposition of hourly operational caps as a means of congestion management has faced little resistance, their decision to withdraw slots from current holders and auction them has been opposed by most legacy airlines, several

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[54] A related concern is that implementing auctions and congestion pricing would reduce the incentive to increase capacity; however, the inefficient use of resources does not provide the justification for expansion. Furthermore, auctions would generate revenue that could be used for justified expansions.

[55] A concern that competitive pressures in the industry may be reduced stems from the possibility that such pricing would increase the entry barriers in the airline industry and thus protect legacy air carriers at the expense of smaller carriers and new entrants. Legacy air carriers also have access to resources to buy slots. On the other hand, the inefficiency of current operations should be weighed against these potential implications of, as well as the benefits from, market-based pricing.

[56] International flight times are somewhat inflexible, so the profitability of these flights would decline. There is a narrow time window both to leave New York for Europe and to leave Europe for New York to arrive on the same day because of European airports' slot rules and the North Atlantic Air Traffic Control system.

[57] Even if foreign carriers would be subject to congestion pricing or auctions, congestion pricing or auctions might have a large effect on domestic operations relative to international operations. Foreign carriers with primarily international operations at New York City area airports might endure the higher costs because international flights tend to generate more revenue per passenger than domestic flights. This would benefit foreign carriers relative to domestic carriers because they operate hubs in their home countries and would not be affected by the reduction of U.S. domestic feeder flights. Obviously, U.S. carriers would be adversely affected by the reduced number of such flights.

[58] See the comments of the ATA and Kasper and Lee (2009) before the FAA.

industry trade organizations, and various government entities.[59,60]

Not surprisingly, the FAA does not view the New York City market as generating an efficient allocation of slots. The FAA's concern is that the carriers serving LaGuardia have used some of their existing slots to deny their competitors access to the slots. To minimize the costs of this "babysitting" of the slots, the carriers use very small aircraft. If so, then there is unmet passenger demand at LaGuardia. This has prompted the FAA to encourage carriers to increase the average size of aircraft at the airport. Moreover, the ATA points to measures of concentration that indicate that LaGuardia is not dominated by a small number of carriers.[61]

In summary, the ATA believes that the FAA is attempting to solve a problem—a lack of competition that has caused consumer demand to be unmet—that does not exist. Thus, the auction and the related regulations are simply imposing costs on airlines operating at LaGuardia with no compensating gains.

On the contrary, the FAA views the totality of its proposal as necessary to generate an efficient and dynamically competitive environment not only at LaGuardia, but also at Kennedy and Newark. It views the slot auctions as primarily a long-run congestion management tool. Requiring established airlines to surrender a percentage of their slots would allow the FAA to increase competition inside the airports by providing new and limited carriers the ability to expand their operations. Without a forcible slot reallocation, the FAA argues, established airlines would have little incentive to ever voluntarily offer slots for sale or lease to potential competitors.[62,63]

## CONCLUSION

Airport congestion continues as a major problem at many airports, including the three major airports in the New York City area. Economic theory suggests that this problem might be resolved via a quantity-based mechanism that includes a cap on the slots and a market-based allocation of the slots. However, determining the number of slots that yields an efficient level of congestion is a challenging task. In the present case, the FAA proposed an auction to sell a number of the slots. As with many public policy proposals, "the devil is in the details."

We have provided an extensive discussion of the proposal. Not surprisingly, many of the opponents believed they would be harmed by the proposed changes. Paying higher prices and/or incurring reductions in air transportation services are consequences that, not surprisingly, generate opposition from those likely to be harmed. Many of these opponents are able to avoid paying the full cost for their contributions to congestion. We have also conveyed the key features of the combinatorial auction that would be used to allocate slots. Without question, the FAA's plan to allocate some slots via an auction is more complex than the current system.

Although there is general agreement that a cap on the number of slots is appropriate, the use of the auction to allocate the slots has generated much controversy. The FAA viewed the auction as an essential feature of their plan, but auction opponents argued that it would have been unnecessary to ensure a competitive result. Moreover,

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[59] One argument against the forcible slot reallocations is that the significant reduction in airport congestion intended by the final rules would result mainly from the hourly caps and not the application of auction proceeds realized from auctioning a marginal number of slots.

[60] While we cannot detail all objections here, they are well described in the FAA's final rule documents (*Federal Register*, 2008a,b).

[61] Based on one measure of concentration, the Herfindahl-Hirschman Index, LaGuardia ranked 34th of 40 airports with the largest number of domestic origin and destination passengers for the year ending June 2006. Even this ranking may tend to be overstated because of the consumer option to use other New York City area airports. See the comments of the ATA and Kasper and Lee (2009).

[62] While in the past airlines have been able to reallocate slots among themselves via the buy/sell rule, new and limited carriers have complained that, due to the lack of transparency requirements, established carriers could effectively shut them out of the market by arranging private transactions with other carriers, refusing to sell slots, or refusing to provide meaningful lease terms.

[63] Even though the overall number of slots available at each auction may be small relative to the total daily slot operations at each airport, given that the FAA intends to auction slots available during each peak operating hour, the awarding of even a small number of them will begin to establish the dollar value associated with the right to take off or land within a particular window of time. Moreover, once a monetary value is placed on a slot, it may be more difficult for established airlines to justify keeping those slots whose current best benefit is to keep competition at bay at the expense of clogging up the system.

and especially disconcerting to some airlines, the value capture feature of the proposed auctions would have required payments by airlines to the FAA for some slots that they previously received free of charge. Clearly, these opponents were not mollified by either the plan to use these proceeds for projects to mitigate delay and congestion or that auctions might be the least costly way of generating such funding. Without an auction, the FAA believed that the already-established carriers would have an unfair advantage. On the other hand, the opponents argue that these carriers are using the existing slots efficiently and that the existing secondary market works to ensure that slots are transferred to those airlines placing the highest values on the slots.

As of now, the opponents of using an auction to allocate slots have won the political battle. Whether a similar proposal will resurface and generate sufficient political support remains to be seen.[64]

# REFERENCES

Aaronson, Scott. "The Limits of Quantum Computers." *Scientific American*, March 2008, pp. 62-69; www.cs.virginia.edu/~robins/The_Limits_of_Quantum_Computers.pdf.

Adar, Zvi and Griffin, James M. "Uncertainty and the Choice of Pollution Control Instruments." *Journal of Environmental Economics and Management*, October 1976, *3*(3), 178-88.

Bomkamp, Samantha. "Transportation Dept. Scraps NYC Slot Auctions." ABC News, May 13, 2009; http://abcnews.go.com/Business.wirestory?id=7576322.

Brueckner, Jan K. "Price vs. Quantity-Based Approaches to Airport Congestion." *Journal of Public Economics*, June 2009, *93*(5-6), pp. 681-90.

Caterinicchia, Dan. "DOT Proposes Slot Auctions to Reduce Congestion at NYC Airports." *USA Today*,

May 16, 2008; www.usatoday.com/travel/flights/2008-05-16-new-york-slot-auctions_N.htm.

Coase, Ronald H. "The Problem of Social Cost." *Journal of Law and Economics*, October 1960, *3*, pp. 1-44.

Cohen, Jeffrey P. and Coughlin, Cletus C. "Congestion at Airports: The Economics of Airport Expansions." Federal Reserve Bank of St. Louis *Review*, May/June 2003, *85*(3), pp. 9-25; http://research.stlouisfed.org/publications/review/03/05/Cohen_Coughlin.pdf.

Cohen, Jeffrey P. and Coughlin, Cletus C. "An Introduction to the Two Rate Taxation of Land and Buildings." Federal Reserve Bank of St. Louis *Review*, May/June 2005, *87*(3), pp. 359-74; http://research.stlouisfed.org/publications/review/05/05/CohenCoughlin.pdf.

Cramton, Peter; Shoham, Yoav and Steinberg, Richard, eds. *Combinatorial Auctions*. Cambridge, MA: MIT Press, 2006.

Czerny, Achim I. "Congestion Pricing vs. Slot Constraints to Airport Networks." Working Paper No. 2006-02, Berlin University of Technology, Center for Network Industries and Infrastructure, 2006.

Dubner, Stephen J. "Want to Fix New York Air Congestion? Shut Down LaGuardia." *The New York Times*, May 14, 2009; http://freakonomics.blogs.nytimes.com/2009/05/14/want-to-fix-new-york-air-congestion-shut-down-laguardia/.

*Economist*. "Cap and Trade, with Handouts and Loopholes." May 23, 2009, pp. 33-34.

Federal Aviation Administration. "Auction Procedures for Allocating Slot at LaGuardia, John F. Kennedy International, and Newark Liberty International Airports." September 15, 2008a; www.fbo.gov/index?s=opportunity&mode=form&id=0fd39be76893145ad96b6c0b959203d1&tab=core&_cview=1&cck=1&au=&ck=.

Federal Aviation Administration. "2009 New York Slot Auctions Bidders Seminar" (slide presentation), December 5, 2008b; www.faa.gov/about/office_org/headquarters_offices/aep/ny_auctions/media/bidder-seminar-2009-new-york-slot-auctions-2.pdf.

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[64] See Levine (2009) for a proposal that attempts to generate an efficient allocation of slots using an auction, while also attempting to overcome the objections to the FAA's proposal.

*Federal Register*. "Congestion Management Rule for John F. Kennedy International Airport and Newark Liberty International Airport; Final Rule." October 10, 2008a, *73*(198), pp. 60544-60571; www.fly.faa.gov/ecvrs/circulars/FR_JFK_and_EWR_final_rule_101008.pdf.

*Federal Register*. "Congestion Management Rule for LaGuardia Airport; Final Rule." October 10, 2008b, *73*(198), pp. 60574-60601; www.fly.faa.gov/ecvrs/circulars/FR_LGA_Final_Rule_101008.pdf.

Federal Trade Commission. "Comment of the Staff of the Bureau of Economics of the Federal Trade Commission—In the Matter of Congestion Management Rule for LaGuardia Airport." Docket No. FAA-2006-25709, Notice No. 08-04; www.ftc.gov/os/2008/06/V080015comment.pdf.

Holland, Jesse J. "Court Blocks FAA Auction of Airport Slots," ABC News, 18 December 2008; http://abcnews.go.com/print?id=6422027.

Kasper, Daniel and Lee, Darin N. "Supplemental Notice of Proposed Rulemaking Congestion Management Rule for LaGuardia Airport." Comments before the Federal Aviation Administration, Docket No. FAA-2006-25709, June 16, 2009; http://lecgaviation.com/thought_leadership/LECG%20Comments,%20June%2016.pdf.

Levine, Michael E. "Airport Congestion: When Theory Meets Reality." *Yale Journal on Regulation*. Winter 2009, *26*(1), pp. 37-88.

Morrison, Steven A. and Winston, Clifford. "The Effect of FAA Expenditures on Air Travel Delays." *Journal of Urban Economics*, March 2008, *63*(2), pp. 669-78.

*New York Aviation Rulemaking Committee Report.* December 13, 2007; www.faa.gov/library/reports/media/NY%20ARC%20Final%20Report.pdf.

Stavins, Robert N. "Correlated Uncertainty and Policy Instrument Choice." *Journal of Environmental Economics and Management*, March 1996, *30*(2), pp. 218-32.

Telser, Lester G. "The Usefulness of Core Theory in Economics." *Journal of Economic Perspectives*, Spring 1994, *8*(2), pp. 151-64.

Tietenberg, Tom. "Tradable Permit Approaches to Pollution Control: Faustian Bargain or Paradise Regained?" in M.D. Kaplowitz, ed., *Property Rights, Economics, and the Environment*. Stamford, CT: JAI Press, 2000, pp. 155-76.

Weitzman, Martin. "Prices vs. Quantities." *Review of Economic Studies*, October 1974, *41*(4), pp. 477-91.

Whalen, W. Tom; Carlton, Dennis W.; Heyer, Ken and Richard, Oliver. "Proposal for a Market-Based solution to Airport Delays." Economic Analysis Group of the Antitrust Division of the U.S. Department of Justice Discussion Paper, EAG 07-14, October 2007; www.usdoj.gov/atr/public/eag/227380.pdf.