Airport Capacity: The Problem of Slot Allocation

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1. Introduction

Worldwide airline passenger numbers have more than doubled in the last 20 years and this increase in the demand for air travel has led to increased demands being placed on capacity at airports. Many airports are already experiencing excessive demand from airlines relative to supply and forecasts show that demand for air travel will continue to grow in the future, further exacerbating capacity problems at airports.

The amount of capacity needed for an aircraft to take off or land is referred to as a 'slot', defined under UK and EU law as the scheduled time of arrival or departure available or allocated to an aircraft on a specific date at an airport. The supply of airport slots is limited by terminal and stand infrastructure and by the availability of runway capacity, but the most frequent cause of airlines not being able to schedule flights at desired times is the lack of available runway capacity.

For the Summer 2000 season at Heathrow and Gatwick airport, total demand for slots exceeded supply by over 15%. Many UK airports face excess demand for slots at peak times, while Heathrow and Gatwick experience excess demand throughout most of the day. (DotEcon, 2003) Therefore there would appear to be an urgent need to devise a solution to deal effectively with these capacity problems.

Clearly one means of alleviating capacity problems is to expand the infrastructure and make more slots available. However, there are many reasons why the expansion of runway capacity has failed to keep pace with the demand for flights. Starkie explained that "Many airports are still publicly controlled utilities subject to political whims and often tight budgets, expansion may be restricted by environmental limitations and other controls, and building new runways or extending existing ones is not an easy task" (Starkie, 1998).

Whilst investment in new capacity is limited by financial constraints, planning requirements and environmental concerns and is, hence, subject to long lead times, improved technology and more efficient runway utilisation can enable airports to achieve increases in capacity utilization. For example, In the 1970s, the capacity of Heathrow and Gatwick airports combined was estimated to be 440,000 annual movements, however in 1997, Heathrow alone handled 426,000 (Starkie, 1998). Even in the period from 1991 to 1999, maximum hourly runway capacity in the summer seasons at Heathrow increased from 74 to 84 and at Gatwick from 41 to 48 slots. (DotEcon, 2002). However, at high rates of capacity utilization service reliability problems and questions of how to ensure an efficient allocation of capacity amongst competing airlines emerge. Therefore, the scope for continuing to squeeze more capacity out of the existing infrastructure, whilst maintaining a reliable service and an efficient allocation of services, must be limited.

To be clear, it is useful to distinguish between two effects of shortages in capacity - congestion and scarcity. Congestion at airports represents the expected delays resulting from the transmission of delays from one aircraft to another. The use of an additional slot at an airport reduces the airport manager's ability to recover from an incident and increases the probability of delays. This becomes worse at high levels of capacity utilisation, since there is a lack of spare capacity to recover from any delays. Congestion costs are the costs associated with these expected delays. In this way, the consumption of additional capacity and the resulting congestion at the airport imposes delay costs on airlines and, ultimately, passengers. Scarcity at airports represents the inability of an airline to obtain the slot they want in order to operate a particular service. The inability of the airline to provide the service it estimates will best meet its customer's demands represents a cost to society equal to the social value of that service, where social value comprises profit to the airline, consumer surplus to the passengers and net benefits to third parties for instance from changes in pollution (which may be positive or negative).

We are concerned here with the problem of how to balance the demands of competing airlines in order to make best use of the existing fixed airport capacity. At airports where there are competing demands for slots from different carriers, this involves making choices about which slots are allocated to which carriers. In principle, slots are efficiently allocated when used by those carriers that can generate the greatest overall social benefit from them. The problem then becomes how to identify, or how to get carriers to identify, the social benefit associated with a slot.

The current system of allocation at most airports, based mainly on administrative procedures and historic precedence, is widely viewed to be economically inefficient because it does not adequately reflect the scarce nature of airport slots and does not include an explicit mechanism for ensuring that slots are allocated to those who attach the highest value to them. A number of alternative systems that could be used to allocate slots based on a reflection of their value as a scarce resource have been proposed. Slots could be priced to better reflect their value and opportunity cost, auctioned in a way that allocates them to the optimum bidder who can best utilise the resource, or traded on a secondary market following an administrative allocation, whereby the trading of slots could enable achievement of a more efficient outcome. Alternatively, some combination of administrative and pricing mechanisms might be used. Yet few of these alternatives have been tested in real-world conditions, despite over 20 years of research and investigation into the subject.

This paper provides an overview of the literature on airport slot allocation and pricing. We begin by describing the nature of the problem and assessing the current European system in allocating slots, before going on to examine various other types of allocation methods and the views of different authors in the literature. In particular, we examine the relative merits of pricing, auctioning, secondary trading and administrative arrangements. In undertaking our review and in drawing our conclusions, we also draw on our knowledge of the literature and experience of the allocation of scarce capacity within the rail sector, where similar problems arise.

2. Existing Slot Allocation Mechanisms

Slot allocation in the EU is governed by the European Commission's regulation on airport slot allocation (Council Regulation (EEC) No 95/93). The regulation was broadly based on the well-established slot scheduling procedures devised by the International Air Transport Association (IATA) and, in theory, its objective was to encourage the efficient use of airport capacity through the optimal allocation of slots (DotEcon, 2002). Its principles were based on EU policy (EEC No 2408/92) to 'facilitate competition and to encourage entrance into the market.'

The regulation states that when demand exceeds supply, arrival and departure slots should be allocated to a coordinator who is instructed to handle the task in a neutral, impartial and transparent way. The coordinator has to participate at the international timetabling conferences that take place twice a year arranged by IATA for the summer and winter seasons. The conference provides an opportunity for airlines and coordinators from airports around the world to meet and agree slot allocations for the coming seasons.

Before the timetabling conferences, airlines submit their (confidential) demands for slots to the coordinator. These requests are compiled and a draft proposal about the number and timing of slots allocated is sent back to each operator before the opening of the conference.

The first step for each allocation period is that existing slots are 'grand-fathered'. This principle of historic precedence allows incumbent airlines with existing slots to be given priority to the same slots in the next timetable. It was designed in an era when there were few if any capacity constraints on airports and has survived to the present day as it is seen to be 'reliable' as the allocated slots are generally usable. If the historic right to the slot is to be protected for the next period, the slot has to be used at least 80% of the time in the current period. This is the 'use-it-or-lose-it' rule.

There are differing views on the issue of grandfather rights. New entrants claim that grandfather rights deny them opportunities to enter the market and compete against the major carriers. On the other hand, incumbent carriers – those with the grandfather rights - argue that it maintains stability and continuity in scheduling which facilitates long-term planning (Pagliari, 2001). One particular impact of the use-it-or-lose-it rule is that it creates powerful incentives for airlines to hang on to slots, even if they are not making optimal use of them, e.g. because airlines could generate 'scarcity rents' defined as additional revenues that accrue because competition is limited by capacity constraints. Hence, the incumbent carriers may try to retain the slot, even if this involves operating loss-making flights with low load factors.

Once the grandfather rights are confirmed, the remaining slots are allocated to a 'slot pool' which also contains any newly created slots through increases in hourly schedule limits, slots returned voluntarily and slots otherwise unclaimed by anyone. Slots in the slot pool are allocated free of charge by the slot coordination body in the twice yearly allocation process. It is believed, however, that the turnover of slots is typically small as in Summer 2000, 97% and 89% of slots at Heathrow and Gatwick respectively were grandfathered (DotEcon, 2002).

In an effort to encourage competition and new entry, up to 50% of the slot pool is set aside for new entrant airlines, defined as those carriers with less than 3% of slots at a fully co-ordinated airport. However, a large percentage of these slots are believed to be of limited commercial value and the number of slots available may not be sufficient to secure the scheduling of a new route. The size of the pool may only permit new entry from very small carriers offering low frequency services, which are unlikely to pose significant competitive challenges to high frequency services offered by established carriers. From an economic efficiency perspective however, it is questionable as to whether it is really sensible to encourage new entry at already capacity constrained airports. It may be better simply to encourage the current players in the market to utilise the existing infrastructure in a more efficient way.

In the UK, the EU slot allocation procedure is developed into three sets of criteria which, in order of importance, are:

- primary criteria, which includes historical precedence, schedule change, new entrants, introduction of year-round services;
- secondary criteria, which includes the size and type of the market served, competitive requirements, worldwide scheduling constraints, needs of the travelling public and frequency of operation; and
- other local criteria specific to UK airports, which include night flying restrictions, licensing issues, minimum stand usage and effect of traffic distribution rules.

In the cases of conflicting requests, Heathrow airport uses a priority list. A waiting list of outstanding slot requests is maintained and if two conflicting requests have the same priority, the date of request determines the final outcome (DotEcon, 2002).

During the timetabling conference, the initial proposals are discussed between the operators and an agreed allocation is established. Once an allocation has been established, there may be further ongoing negotiations between airlines to seek mutually beneficial exchanges of slots. This is the one for one transfer of slots with no sale involved. The process of buying and selling slots, usually referred to as 'slot trading', is prohibited under current EU regulations. However, in March 1999 a British court did allow slot exchanges accompanied by monetary side payments, so whilst it is something of a 'grey area', it would appear that airlines may still illegitimately acquire slots through a 'backdoor' route. That is, they can request unallocated slots with low commercial value from the coordinators and then swap them for more attractive slots and make a payment to the slot's current user at the same time. This may lead to secondary market trading in airport slots. It is believed that it may bring advantages in terms of efficiency, as the monetary payments would create gains from trade if an airline currently holding a slot is not the most efficient user. (See section 5).

Many believe that the current slot allocation procedures perform poorly and do not allocate slots with the objective of generating the greatest benefit for consumers and the economy at large. Allocating slots on the basis of historic precedence is inconsistent with obtaining the greatest possible benefit from available airport

capacity as a slot is allocated to the current user even though it is possible that a different user could generate much greater social benefit from it (DotEcon, 2002).

3. Pricing

Some authors argue for pricing to be used as a rationing device to allocate scarce capacity to those who attach the highest economic value to it. They believe that prices should be derived so as to reflect the opportunity cost of slots. In this way, an airline's slot requests and usage will take account of the benefits that could have been generated if the slot was used by another airline. Alternatively, Leveque (1998) argues that those carriers who are willing and able to pay a higher price for the slots are able to do so because they are maximising the efficiency of the slots; i.e., maximising their revenues per slot.

One relatively straight forward approach to pricing would be to differentiate the price of airport slots between different periods. There are often significant variations in the demand for slots at different times of day, on different days of the week and during different months of the year which can result in airports operating at full capacity at peak periods, whilst many slots may remain unused at off-peak periods. At an airport that experiences capacity shortages at peak hours and in peak months, despite having significant excess supply for most of the time, it may be possible for the coordinator to accommodate all requests for slots, but not necessarily at the times requested (DotEcon, 2002). However, if the price of a peak period slot was higher than the price of an off-peak slot the demand for slots may be rescheduled; a high peak price may induce at least part of the demand to use airport capacity at off-peak periods. The extent to which this occurs will depend on the willingness of airlines to switch between slots at different time periods, which in turn depends on factors such as:

- the time sensitivity of their target customers (business travellers are typically very time sensitive and can be charged premium prices, whereas leisure travellers are typically more price sensitive);
- the need to make efficient use of their assets by optimising aircraft usage;
- their ability to coordinate landing and departure times with the other airports on the routes they serve; and
- the need to coordinate a particular flight with others running on the same route.

Differentiation could be introduced via an iterative process, whereby higher prices for peak and lower for off-peak slots were introduced in phase one and the airport authority would then assess whether or not excess demand has been eliminated. If not, the peak-price for the subsequent time period could be raised, where as if the price is too high and capacity is not being fully utilised, the price could be reduced. However, Nilsson highlights that this process of iteration could take several periods to arrive at an equilibrium solution and meanwhile, administrative allocation decisions would still have to be taken for the excess demand situations. He argues that it may be more efficient to have an auction-type mechanism, where operators are asked to quote prices for the slots they want, rather than having to test different price levels (Nilsson, 2002).

Using the price mechanism as a means of rationing demand would involve the transfer of economic rent from the airlines to the airports (or, in the case of a tax, to the government). In an environment where many airlines are already less profitable than airports, a further transfer in this direction is likely to be strongly resisted.

Furthermore, pricing in this way may have a negative impact on airline competition, in that the major airlines are likely to be able to better afford the higher prices for slots than smaller operators or new entrants. In a policy environment where competition is viewed as being 'good' for the market, these competitive concerns are likely to be another barrier to implementation.

If the higher charges for slots in the peak periods are reflected in passenger fares, only those passengers with the highest willingness to pay will choose to travel during these times. Passengers who are not willing to pay the peak price may shift to flights at different times, use different modes of transport or not travel at all. This may lead to airlines that find themselves operating flights that carry insufficient passengers rescheduling or reducing these flights.

4. The Role of Auctioning

Auctions come in many different formats. Some of the main types are:

- The 'English auction' - The auctioneer starts with a reserve price, which is the lowest price that the seller of the good is willing to part with it for. Bidders successively offer higher prices until no bidders are willing to increase the bid further and a single bidder remains. This bidder wins the auction and will pay the value of their last bid (the highest bid). The optimal bidding strategy is to stay in the bidding for as long as the current price is lower than the bidder's valuation of the lot. The bidder's valuation is the maximum price they are willing to pay. Once the price exceeds that value, they will drop out of the auction. This results in the lot being sold to the bidder with the highest valuation at a price just above the second highest bidder's valuation.

- The Dutch auction - The auctioneer starts off with a high price and gradually lowers it by steps until someone is willing to buy the good. These auctions can proceed very rapidly, which is one of their main virtues.

- The 'First-price sealed bid auction' - Sealed bids are submitted by bidders without the knowledge of the bidding behaviour of other bidders. In this case, the bidder's actions are independent. The highest bid wins the auction and the winning bidder pays the price equal to their bid. The higher they bid, the higher the chances of winning but they will have to pay more if they succeed. If the bidder bids their true valuation, in the case of winning, the bidder would not enjoy any surplus. They would have to pay the maximum that they were willing to pay. But if they bid less than their true valuation, they would enjoy a surplus, but reduce their chances of winning. The optimal bidding strategy is for bidders to bid less than their true valuation of the lot, depending upon what they expect others to bid.

- The Vickrey auction - like the sealed-bid auction described above but with the critical difference that the good is awarded to the highest bidder but at the second highest price, ensuring that the 'winner' enjoys some surplus.

Grether et al (1989), suggested organising the primary market for airport slots as a 'sealed-bid, one price auction'. Each bidder submits a sealed bid for each unit desired indicating the maximum price they are willing to pay. They do not have knowledge of the behaviour of other bidders. The bids are then arranged from highest to lowest. If x units are auctioned, then the highest x bids are accepted. The price paid by each of the winning bidders is the value of the lowest accepted bid.

Nilsson (2002) provides an example of how the mechanism might work. Suppose bids are submitted for a specified part of a day at an airport. It is assumed that carrier A submits a single bid for 450; carrier B submits three bids of 3000, 700 and 400; carrier C submits two bids of 550 and 425; and carrier D submits three bids of 1500, 500 and 350. Suppose that six slots are available for this period. The slot that was last accepted would then go to bidder A (grandfather right) while bidders B, C and D would each get one slot less than they want. All six allotted slots would go at price 450, as it is the lowest accepted bid, even though carrier B submitted the bid 3000.

This mechanism was aimed to achieve the optimal bidding strategy. Each carrier would bid close to the maximum they are willing to pay, in order for their bid to be accepted. This value is directly related to the profits the flight will generate. As a result, slots may be allocated to those airlines that value them the highest. As the highest bids do not determine price, profits from carrier's most profitable flights are protected. Price is determined by the lowest accepted bid and therefore by the least profitable flight in the market. However, it can be argued that carriers may inflate bids in order to for their bid to be accepted, knowing that they probably would not have to pay that value. In that case, the bid would not reflect the carrier's maximum willingness to pay.

The higher density routes may bid up the market price of slots, hence squeezing out smaller-scale services. This problem may be eliminated by reserving a certain number of slots to be put to the use of serving small communities. The EEC Regulation 95/93 tried to handle this problem by allowing special provisions for regional services under strict conditions. Fully coordinated airports could reserve slots for domestic flights conditional that the route was considered to be vital to the development of a particular region, the slots were being used for that route at the time of implementation of the regulation and no other carrier was operating that route and there was no other mode of transport offering an adequate service. The reservation of these slots ends when another carrier operates an equally frequent service. Slots could also be reserved on routes where public service obligations (PSOs) had been imposed under EU legislation. However the DETR (1998) did not believe it was possible for the UK to reserve slots where a PSO was not imposed. Considerable opposition was expected from within the industry to this setting aside of slots for these regional or smaller scale routes. BAA felt that 'ring-fencing' in this way could only be done at the expense of other services that provide greater benefit to the UK economy. However they were likely to feel that way due to the fact that regional services are typically less profitable and use smaller aircraft carrying a small number of passengers. (DotEcon, 2002)

Certain types of aircraft use more capacity than others and an increase in the use of these types of aircrafts would lead to a loss of airport capacity. Nilsson suggests that a way to handle this would be to make operations that placed disproportional demand on capacity by requiring more slots than other operations, more costly to bid for them. It would be necessary in an auction to bid for two slots for large aircrafts. (Nilsson, 2002) An example taken from DotEcon (2002) illustrates below how the size of the aircraft affects slot capacity available for use by other aircraft.

Assume that there are three bidders for slots in a particular time window. Also assume that bidders want to operate different aircraft, which is reflected in the amount of terminal capacity required by each bidder.

Bidder A bids amount 200 and requires runway capacity of 1 unit and terminal capacity of 3 units.

Bidder B bids amount 150 and requires runway capacity of 1 unit and terminal capacity of 2 units.

Bidder C bids amount 100 and requires runway capacity of 1 unit and terminal capacity of 2 units.

Assume that runway and terminal capacity available for this period is 2 units and 4 units respectively.

Therefore if bidder A wins the auction, no further slot would be available for this period, as terminal capacity would bind. However, both bidders B and C could be accommodated within the limits given by the available runway and terminal capacity; two slots would become available. The combined sum of the bids offered by bidders B and C exceeds the sum offered by bidder A (250>200). Therefore bidders B and C should be declared the highest bidders even though neither of them has individually offered the highest amount. But if bidder A was to bid 300, then it should be deemed to be the highest bidder as the value it generates is higher than the combined value of B and C. However this implies that existing capacity would not be fully utilised.

Many believe that the use to which the funds generated by the sale of slots is put to is a very important concept. Funds generated by the sale of slots may be used to expand airport capacity, eg, by the establishment of satellite airports, building more runways. The sale of slots would provide a natural and economically efficient way of recovering the costs.

Airport operators who receive the funds may act as monopolists. The airport operator may enjoy market power in the provision of services and have an incentive to restrict capacity in order to drive up the price of slots. The airport operator could then enjoy the benefits of the revenues by diverting them to other uses rather than expanding capacity. As Carlsson (2002) suggested “Since the revenues from the user charges can be higher when capacity is too small, the incentives from infrastructure investments might be distorted.” It is thought that if runway capacity were limited by planning and environmental concerns, it would be inappropriate for the airport operator to enjoy scarcity rents resulting from these limitations. In the case where the funds cannot be

set to expand capacity, Nilsson suggests that they should be used to encourage off-peak traffic by a negative lottery of the sealed-bid, one price type. Carriers bid negatively, indicating the amount of subsidy it would take to persuade them to provide off-peak services. Each carrier operating at a subsidised hour would receive a subsidy equal to the lowest accepted (negative) bid.

Another route for the scarcity rents associated with limited capacity may be to the government, subject to providing airport operators with a reasonable return on the investments it makes in capacity.

Nilsson believes that it would be difficult for a carrier to utilise an auction process to monopolise an airport. Collusion would be difficult if auction rules were modified so that neither winners nor bids were announced and slot trading rules could be designed to conceal the identities of the other carriers involved. However it could be argued that it would be difficult to conceal the identity of winners, as it would become public knowledge once operation began, unless they traded their slot immediately. The act of driving up slot prices to prevent competition may use up all the presumed monopoly profits. Also the funds would be destined for capacity expansion, which would further undermine any monopolistic tendencies. If monopolistic tendencies occurred, a monopoly would only be effective if it could withhold supply. In the case of airports, this would lead to unused slots or used for operations involving small numbers of passengers. Revenues from many of the operations may not cover the price paid for the slots and the existing use-it-or-lose-it makes driving competitors away very costly.

Nilsson argues in favour of auctions as the means to establish the price of slots, stating that "The main argument behind the proposal comes from within the industry: In order to keep the airline industry reasonably competitive, it is of strategic importance to provide access to scarce airport capacity on equal grounds for all airlines, large and small, incumbents and entrants." (Nilsson, 2002). DotEcon (2002) also argue in favour of auctions, stating that "A transition to a market-based allocation system with appropriate safeguards against concentration of slots would improve efficiency, encourage competition and yield significant benefits for consumers" (DotEcon, 2002). However, Grether et al (1989) found that the main reason why the auction market mechanism was not being implemented was due to the fierce resistance from airlines.

As with pricing, larger carriers are likely to be in a much stronger financial position to acquire the slots. Carriers with large market share are likely to have much deeper pockets and have a greater chance of winning slot auctions than new entrants and carriers with small market share. Abeyratne (2000) explained that "the sale of slots, although claimed by some as pro-competitive, in that it would attract fierce competition for the slots offered for sale, is considered by many as unduly oligopolistic and favouring only a few powerful air carriers of the world" (Abeyratne 2000). A regulator may be able to ameliorate these competitive issues but their job would be far from easy.

Whilst slot auctions appear attractive as bidders have an incentive to reveal their valuation for the capacity if the auction is properly designed, a powerful practical argument against the use of auctions relates to their complexity. Operators are very likely to need networks of slots; multiple slots at a node and complementary slots at

other nodes. Thus, slots would have to be auctioned in packages and there are many different ways in which they might be packaged, some of which may favour certain types of carrier over others. Hence, the auction designs for these tend to end up being highly complex. (Pels et al, 2002).

5. A Secondary Market for Slot Allocation

Slots can be allocated through both primary and secondary market mechanisms. Primary allocation refers to the distribution of runway slots from the regulator or airport to airlines. This market is currently implemented in Europe by administrative means such as grandfathering. Secondary allocation refers to the redistribution of slots among airlines. This may be through slot exchange (barter trade) and monetary trading via for example, auctions or face-to-face transactions.

The CAA (2001) asserts that legitimising a monetary secondary market in slots offers scope to improve the efficient allocation of scarce airport capacity by confronting the users of grandfather slots with the true opportunity cost of slots held. Such a market for airport slots has existed for a number of airports in the USA since the mid-1980s, though a secondary market involving monetary payments remains illegal in the EU.

From April 1986, the four major US airports (Kennedy, LaGuardia, O'Hare and National) have used a secondary market based mechanism known as the 'buy-sell-rule'. Capacity was still allocated based on grandfather rights but in addition, the new rule allowed any carrier to purchase, sell, trade or lease slots. It was possible to not only buy or sell slots on a permanent basis but also on a temporary basis. The market was restricted to slots used for domestic services, which were divided into two groups: air carrier slots and commuter slots. However the market was overseen by the Federal Aviation Administration (FAA), which stated that air carrier slots could be traded without restriction while commuter slots could not be bought by the large carriers and all other slots, including those for international flights, were excluded from the trading market. Carriers had to 'use-or-lose' their slots. If slots were not used in a predetermined minimum time in a period of two months, the slots had to be returned to the FAA. Slots that had become available were assigned to a pool and reallocated using a lottery with 25% initially offered to new entrants.

DotEcon suggested that a move to time-limited usage rights would enhance the benefits of an auction, as short-term usage rights would ensure that a significant proportion of slots were regularly reallocated.

Starkie (1998) found that there was an initial surge of activity as airlines acquired the slots that they believed they could use best and disposed those that could be sold profitably. After this sorting out, the number of outright sales fell but there was an increase in short-term leases, reflecting the fact that some carriers require the use of a slot at only limited times of the year.

Starkie explained that in the absence of a pricing mechanism, evidence from O'Hare airport in Chicago supports the case for having a secondary market in slots, as it is likely to increase the efficient use of slots at congested airports. But it must also be considered that the emergence of a backdoor secondary market without formal

regulation could have many problems. There is the risk of market power concerns as slots could become concentrated amongst relatively few carriers thereby giving them strong market positions. The European Commission (EC 2001) criticized slot trading for not easing market entry but reinforcing the dominant position of incumbent carriers at congested European airports. There may be a lack of transparency, as an airline that is planning to sell a slot would need to find a buyer. Without a formal market, it may be difficult to identify potential buyers, especially potential new entrants. Established airlines may therefore be the natural parties for a seller to approach. There is also the risk that this secondary market may not promote public interest and may eliminate particular routes that had been safeguarded.

Czerny and Tegner (2002) felt that the current regulatory framework for the allocation of runway slots in the EU neglected the positive effects of market mechanisms. The trading of runway slots was rejected even though it led to an increase in overall efficiency in the US market. DotEcon believes that there is a strong case on efficiency grounds for the development of a secondary market in slots, but if it is not regulated properly, it could allow airlines to gain market power. Therefore to address these concerns, slot trading could be implemented with a strict application of competition law.

6. Conclusion

It is highly unlikely that the current system of slot allocation results in slots being held by the most efficient user or those users who place the greatest value on the slots. It is based on historical precedence, where the existing owners are given priority to own the same slots in the next season, and does not encourage competition from new entrants; even though a slot pool is created for this use, it is argued that the slot pool contains slots of a low commercial value, and insufficient slots to allow a new entrant to create a service or route that could compete with incumbent airlines.

Investment in infrastructure expansion is limited by environmental concerns and long lead times. Even if there is scope for demand being met through new infrastructure, in the long run demand is expected to rise and scarcity is still expected to persist at particular times and at particular airports into the foreseeable future.

Pricing may be a good way to reallocate the demand for slots from peak to off-peak periods, hence reducing scarcity at peak periods. For example, if there were 5 slots available during a peak hour, peak pricing would ensure that the carriers who valued the slots most highly would have the right to use them. It may lead to the withdrawal of a number of services where business is dependent on peak period operation. In terms of implementation, it would be difficult to calculate what prices to charge. One proposal within the rail context is to identify where capacity is constrained and to price equal to the estimated long run average incremental cost of expanding that capacity (NERA, 1998). A second alternative from the rail literature is for the airport authority to attempt to calculate directly the costs involved; for instance, if a flight has to be operated at a different time from that desired, it is possible to use studies of the value people place on departure time shifts to estimate the value to its customers of the cost involved (Nash et al, 2003). Alternatively, a process of iteration towards equilibrating prices may be a pragmatic means of arriving at appropriate price levels,

but the time it might take to arrive at these prices, and the implied distortions along the way, are causes for serious concern.

There is a sizeable body of literature relating to the use of auctions for allocating slots. (e.g., Nilsson, DotEcon, Grether et al). There are many different types of auctions to choose amongst. Nilsson argues that the sealed bid, one price auction - a sealed process where the highest bid is accepted at the lowest bid price - is the most efficient method of allocation as it allowed bidders to reveal their true valuation of the slots, and did not destroy their profits as the lowest bid determined the price. However bidders may inflate bids in order to win the auction, knowing that they will not have to pay that value.

Despite the research in this area, there is little or no actual experience of auctions in this setting. This may be as a consequence of one or more of the identified difficulties and complexities associated with the process. Firstly, there is the issue that small scale services might need to be protected, via a proportion of slots being reserved. Secondly, the different capacity requirements of differently sized aircraft would need to be accounted for within the design of the auction. Thirdly, carriers generally operate services as part of a network and hence require packages of slots rather than individual pairs of slots in isolation. The multitude of ways in which packages might be constructed adds further complexity to the task of auction design.

The use to which the revenue generated from auctions is put to, is a very important issue. This depends on who receives the funds. Airport operators may act as monopolists and restrict capacity in order to drive up the price of slots and the government may use it for other purposes. Where there is a good economic case for expanding capacity, revenue should be used to fund this, though this may not always be possible due to planning restrictions and environmental concerns.

There is a strong case for a secondary market in slot allocation. After the primary allocation of slots via administrative forms such as grandfathering, slots could then be redistributed among airlines in a secondary market through barter trade or monetary trading, as has been the case at four of the busiest US airports. This may ensure that all slots are efficiently allocated to the appropriate users, however the market needs to be regulated to ensure against market concentration concerns.

Although various pricing mechanisms exist and they may have feasible arguments for their use in principle, this may not always be the case in practice. It may be more appropriate to allocate slots using a balance of the mechanisms. This may be through keeping some of the current system of allocation of grandfathering slots, and using peak and off peak pricing for the rest. A secondary market in slot allocation could also exist and a slot pool could be set aside to attract new entrants and allow competition. Regulation will be needed to ensure that the markets operates efficiently. Identification of the appropriate balance between the different methods will require further research in this area.

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