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THE EMERGENCE OF MULTI-AIRPORT SYSTEMS

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Abstract

Large metropolitan regions are often served by two or more airports. The aim of this study is to analyze the driving forces underlying the growth of such multi-airport systems, describe the main relationships between the airports involved, and conclude about their future characteristics. We base this analysis upon the airport systems of two of the world's largest metropolitan areas, i.e., London and New York.

While the total growth in air travel between metropolitan areas can be explained by a number of factors, including rising income and declining airfares, three main determinants are hypothesised that underlie the different rates of growth of the associated airports, i.e., technical (such as airport capacity constraints), economic (such as the changing business models of airlines serving each airport), and political/historical (such as decisions regarding increases in system capacity).

Given the strong increase in world air traffic, multiple airport systems are likely to increase in number primarily due to capacity constraints at primary airports (a technical effect) and growth of low-cost carriers (an economic effect). Political factors can act as both a significant boost to growth and a strong constraint on how this growth can occur.

Keywords

Multi-airport regions, Low-cost carriers, Passengers-aircraft movements, Demand, and Capacity.

I. Introduction

Large metropolitan regions are often served by two or more airports. Table 1 shows the top 11 origin-destination metropolitan regions in the world and the airports that serve them. The primary contributor to the development of these systems is the massive growth of aviation as a mode of transport since World War II – over the past 5 decades worldwide demand for air transport has shown an average growth rate of nearly 9% per year [1]. This growth in demand has been enabled by technology, with the development of aircraft capable of flying faster, further, and cheaper, and driven by growth in population and the economy. These effects are likely to continue, resulting in further increases in demand for air travel into the future [2] – Boeing and Airbus forecast a global average growth rate of about 5% per year over the next 20 years [3,4]. By 2050 conservative

estimates predict a 30-110% growth in passenger kilometres travelled over 2005 levels [5], while more aggressive estimates predict a continued growth of 5% per annum, resulting in an order of magnitude increase in traffic by 2050 [6].

Table 1. Metropolitan Region Airports, 2006 (ranked by passengers handled) [7].

	REGION Airport	PAX (000)		REGION Airport	PAX (000)		REGION Airport	PAX (000)
1	**LONDON**	**137192**	**4**	**CHICAGO**	**95708**	**8**	**DALLAS**	**67100**
	Heathrow	67527		O'Hare	77028		Dallas/Fort-Worth	60226
	Gatwick	34163		Midway	18680		Love Field	6874
	Stansted	23687	**5**	**LOS ANGELES**	**86426**	**9**	**WASHINGTON**	**62542**
	Luton	9425		International	61041		Dulles	22813
	City	2358		Santa Ana – Orange	9613		Baltimore/Washington	21184
2	**NEW YORK**	**106473**		Ontario	7049		Ronald Reagan	18545
	John F. Kennedy	42629		Burbank	5689	**10**	**MIAMI**	**60726**
	Newark - Liberty	35764		Long Beach	3034		International	32533
	LaGuardia	25810	**6**	**ATLANTA**	**84846**		Fort Lauderdale/Hollywood	21369
	MacArthur-Islip	2270	**7**	**PARIS**	**84358**		West Palm Beach	6824
3	**TOKYO**	**99982**		Charles de Gaulle	56849	***22***	**MILAN**	**36703**
	Haneda	65810		Orly	25622		Malpensa	21767
	Narita	34172		Beauvais-Tille	1887		Linate	9696
							Orio al Serio	5240

Associated with the growth in demand for air travel is a required growth in airport capacity to serve that demand. Because of constraints on the growth of individual airports, much of this growth has occurred through expansion of secondary airports, and the corresponding development of multi-airport systems. This trend is also likely to continue. However, building a new airport on a green-field site can be difficult in metropolitan areas with strict planning rules. Thus the large available stock of minor general aviation, military or cargo airports, which can be converted to secondary passenger airports, plays a crucial role in moving from a system where one major commercial airport dominates to one in which commercial operations are initiated at alternative airports.

Since airports can have significant economic impacts, the expansion of existing or the building of new airports is often driven by economic considerations. Economic impacts include direct impacts (the expenditures by firms that operate at an airport); indirect impacts (the expenditures resulting from the aviation service, such as passengers visiting the region); and induced impacts (the expenditures of airport related individuals or firms). As passenger traffic increases, so do revenues for the public and private sectors. The environmental impacts of airports, however, are typically negative, and include particularly local noise and air pollution. Airport operations may be limited by government regulation in order to reduce these effects. The development of multi-airport systems may thus allow a region to reap the economic benefits of increasing demand, but it also adds to that region's environmental problems.

It is therefore useful to analyze the driving forces underlying the growth of such multi-airport systems, describe the main relationships between the airports in the system, and to draw conclusions about their potential future characteristics. We base this analysis upon the airport systems of two of the world's largest metropolitan areas, i.e., London and New York. As shown in Table 1, London and New York experience the highest passenger traffic in the world. Both regions operate multi-airport systems: Metropolitan London has five scheduled commercial airports, while metropolitan New York has three primary airports for scheduled commercial operations.

We continue a discussion of the reasons for emergence of multi-airport systems in Section II. Detailed case studies of the airport systems of London and New York are presented in Sections III and IV. A discussion and conclusions are then presented in Section V.

II. Reasons for the Emergence of Multi-Airports Regions

The growth of multi-airport systems can be explained by three factors: technical, economic and political/historical reasons [8].

1. **Technical Reasons**
   - Demand/Capacity: when demand at a primary airport approaches capacity, operators will be more inclined to grow operations at alternative airports. This may either be a result of increasing delays or, for slot-controlled airports, a shortage of available slots.
   - Limitations/Constraints: airports may have limits on the type of operations which they can support, both in terms of current infrastructure (e.g. runway length) or environmental/technical/geographical restrictions on expansion of operations (e.g. land not being available for future growth). Depending on the type of operations and available aircraft, an airline may be forced to select an alternative airport.
2. **Economic Reasons**
   - Entry of new carriers into a region, particularly with an interest in developing new markets. Low cost airlines particularly require low operating costs in order to enable their business models [9]. They may thus grow operating at airports with low operating costs at the expense of other characteristics, such as proximity to the market [10].
   - Connectivity of the new airport site to the existing or new catchment areas (e.g. existing or planned rail links). Good connectivity to catchment areas increases the growth potential of an alternative airport.
3. **Political-historical Reasons**
   - Incentives for airport growth from local authorities keen to increase their regional connectivity (e.g. the use of public funds to attract more carriers).
   - Political decisions on expansion of airport capacity arising from technical/economic reasons.
   - External factors (e.g. fluctuations in oil prices, expansion or bankruptcy of individual carriers, etc.)

The three factors described are often highly inter-related. In particular, the relationship between the demand for flight operations and airport capacity impacts a number of the factors described above, and is a powerful driver for the growth of airline operations at secondary airports. As demand approaches airport capacity, flight delays increase. Airline operating costs increase with flight delays as fuel usage grows and aircraft utilisation drops. At the same time, passenger satisfaction is reduced as travel time increases, reducing airline passenger demand and thus revenues. In order to mitigate the negative effects of airport capacity constraints, i.e., rising operating costs and declining passenger demand, operators may thus consider growing operations at alternative airports that are less constrained. This outcome is enhanced by the operators of these alternative airports, which may reduce landing fees and introduce other incentives, further reducing the cost of operating there. Such a strategy can be particularly attractive for new entrant low cost carriers, which require low operating costs to run their business models. For the US system, it has been shown by Bonnefoy and Hansman [11] that the development of multi-airport systems allows system growth to scale at the regional level even once individual airports in a region reach capacity. This means that, for example, although traffic at Chicago O'Hare International airport does not scale with demand to the region surrounding the city of Chicago, the combined traffic at O'Hare and Chicago Midway airport

does. However, a suitable secondary airport with available capacity or the regulatory and political will to build new airports is a necessary requirement for this to occur.

When passenger demand in a region reaches capacity, three alternative responses exist to increase airport capacity. The existing airport in the region can increase its capacity by adding infrastructure such as runways, aprons, aircraft stands, gates, building terminals, etc., or by modifying operations. If no capacity can be added, or if it is prohibitively expensive to do so, an existing general aviation airfield or air force/military base in the region may be upgraded to serve as a secondary airport. Alternatively, a new green-field airport may be developed, complementing or even replacing the original airport.

III. The Case of London

Metropolitan London has five scheduled commercial airports: Heathrow, Gatwick, Stansted, Luton and London City, and multiple other airfields for general aviation or military use. Two of London's airports are ranked amongst the thirty busiest airports in the world (Heathrow as 3rd busiest airport and Gatwick as the 25th) [7].

Historical Overview

Heathrow airport was a military airbase that was only finished after World War II, but was then designated the primary London airport, replacing Croydon in 1946 – primarily because of its equipage with paved runways. Other airports were used for commercial operations at the time as well, including Heston and Northolt. However, Heathrow's position as the primary London airport was consolidated in 1950 when all intercontinental operations were transferred there, and in 1954, when British European Airways (BEA) moved its operations to the airport.

At the same time Gatwick airport developed as the primary alternative airport to Heathrow in the London area for smaller airlines and charter carriers, with major improvements being made between 1956 and 1958. In 1984 Virgin Atlantic Airlines started transcontinental operations from Gatwick airport, with it seeing significant growth from 1986 to 1992. British Airways (BA), also a transatlantic carrier and direct competitor to Virgin Atlantic, was fully privatised and merged with British Caledonian in 1987. This gave BA, which already had a presence at Heathrow, a presence at Gatwick also, allowing it to compete directly with Virgin Atlantic. A new terminal was opened at the airport in 1988, enabling this growth. BA can also be seen to respond to the increased competition by increasing traffic at Heathrow.

Luton Airport was officially opened in 1938, but served primarily as a military airbase and as a manufacturing site until the 1950s, 60s and 70s, when it was served primarily by charter airlines. The withdrawal of a major tour operator based at Luton due to liquidation coincided with the first oil crisis (1973) resulting in a drop in traffic. The airport did not start to recover this traffic until 1985-6 when a new terminal was opened and Monarch Airlines and Ryanair – two low-cost carriers – began a small number of scheduled operations from the airport.

Similar to Luton Airport, Stansted Airport was developed from a World War II US military airbase, but only proposed for development as the "third airport of London" in a government White Paper in 1967 [12], at which time it was also served primarily by charter airlines. In 1991 a new terminal was opened at Stansted airport, and Ryanair shifted most of its operations there from Luton. This resulted in an increase in traffic at the airport, and decrease in traffic at Luton. Easyjet – another low cost airline – started operations at Luton in 1995 [13].

London City airport opened for service in 1987, after development through regeneration of the docklands area of London, close to the centre of the city, as an idea of the London Docklands Development Corporation. London City has limited runway length and significant noise restrictions, allowing the airport to only serve smaller aircraft types. Because of its location very close to central London, however, airlines use the airport to serve mostly niche markets and short haul destinations – particularly European business markets, feeding other European hubs like Schiphol, Charles de Gaulle, Frankfurt and Barajas. British Airways plan to start a non-stop business-class only service to New York from the airport in 2009 [14] which, although differing from the current short haul traffic, is a distinctly niche market.

Timeline

Historical data for the five main airports serving London are presented in Figure 1 from 1958 to 2006 according to data from the UK Civil Aviation Authority (CAA) [15,16]. The figure shows the development of passenger traffic and aircraft movements by airport and their percentage distribution across airports. Also shown is the ratio of passenger traffic and aircraft movements, the average number of passengers per aircraft, an indicator of mean aircraft size.

Figure 1 shows the growth of a multi-airport system in London with globally increasing population and prosperity. Heathrow (black diamonds) shows steady growth from the 1950s through to 2004, when it appears to saturate. Gatwick (red squares) grows as the second airport of the region from the late 1960s, at a consistently slower rate than Heathrow, although it does not appear to have saturated by 2006. Stansted (blue triangles) and Luton (brown circles) only start to grow as the third and fourth airports of the region in the 1990s. After 1991 and 1995, respectively, Stansted and Luton airports grew significantly – faster than Heathrow or Gatwick, thus increasing their market share in the system. This growth is almost entirely due to the growth of European and domestic services offered by the low-cost scheduled airlines. It is interesting to note that the traffic at Luton and Stansted – serving primarily short- and medium-haul routes[1] – is such that it was less impacted by the terrorist attacks of 2001 than Heathrow and Gatwick, which serve intercontinental and in particular US-Europe routes. In 2007, however, Stansted started direct intercontinental services to New York, suggesting a possible shift from a secondary airport dominated by low-cost carriers, to a primary-type airport serving all markets. London City airport (grey crosses) has yet to show high growth. In relative terms (right-hand panels of Figure 1) it can be seen that, whilst Heathrow dominates the system throughout the period of analysis, its share of the market has steadily decreased. Gatwick consistently maintains the position of second airport, with an increasing market share until the late 1980s, and is the primary contributor to the reduction in market share at Heathrow during this time. In the 1990s the market share at Stansted particularly, and Luton increases, with a corresponding reduction in the share of both Heathrow and Gatwick. By 2006 Stansted has the clear position of third airport, Luton fourth, and London City airport fifth. Together, Stansted, Luton and London City (black dashed line in Figure 1) account for 35% of total aircraft movements in London by 2006 – just below that of Heathrow at 42%.

[1] At Luton 75% of operations are intra-European and 16% domestic, while at Stansted 82% of operations are intra-European and 12% domestic. Heathrow and Gatwick serve mainly the medium and long haul routes, including particularly intercontinental routes – at Heathrow 55% of operations are intercontinental and 36% intra-European, while at Gatwick 35% of operations are intercontinental and 53% intra-European.

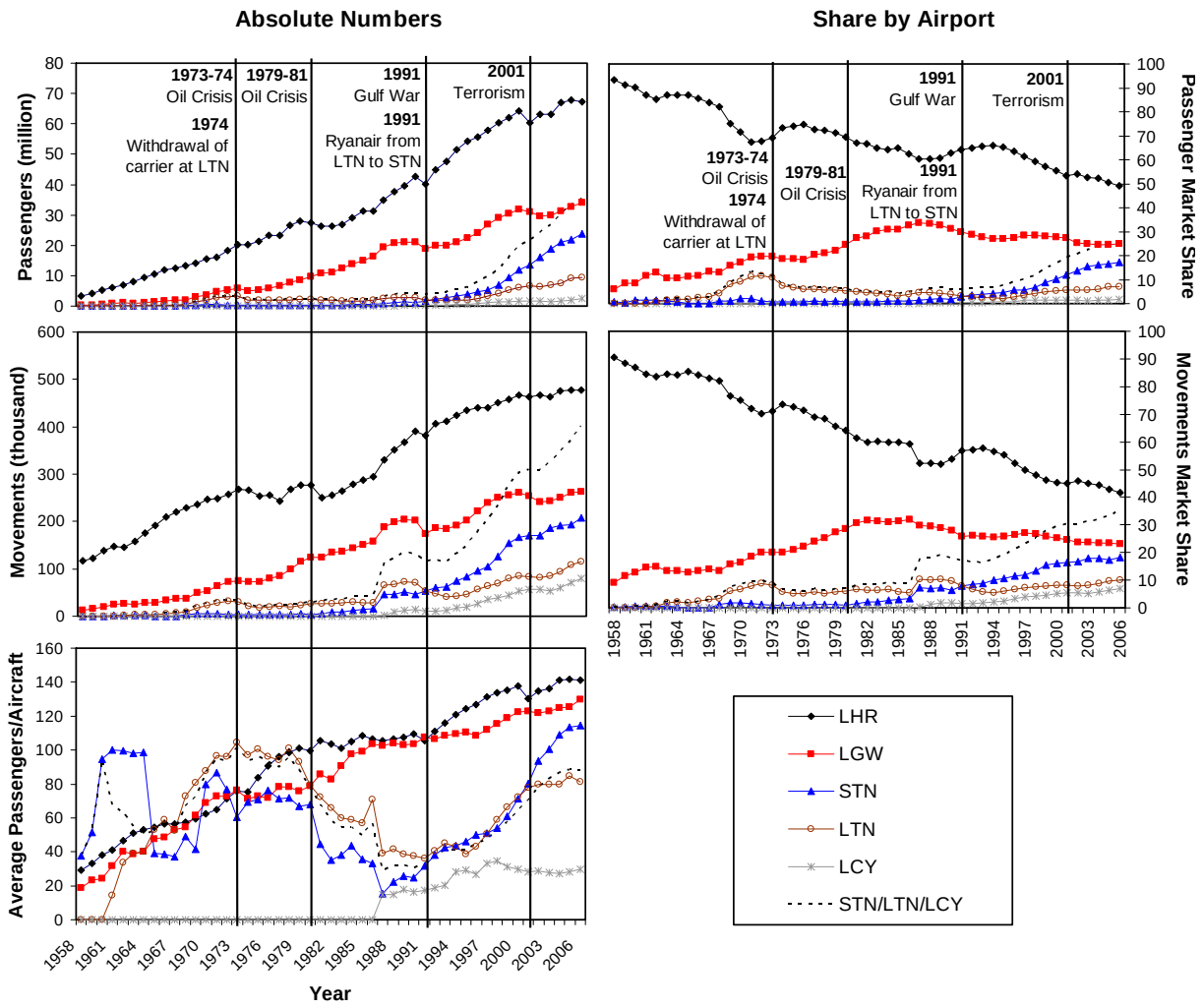

Figure 1. Characteristics of London airports, 1958 – 2006 [15,16].

Mean aircraft size, indicated by the plot of average passengers per aircraft in Figure 1, has steadily increased at Heathrow and Gatwick to 141 and 130 passengers per aircraft respectively in 2006, underlining these airports' role as a hub for intercontinental transport. The majority of the increase in aircraft size was before 2000, after which time mean aircraft size has not changed significantly. At Stansted and Luton mean aircraft size matches that at Heathrow and Gatwick before approximately 1980, when charter carriers were dominant. After 1980 mean aircraft size drops significantly before starting to grow with the entrance of the low-cost carriers in the early 1990s from as low as 15 passengers per aircraft to 114 and 81 passengers per aircraft in 2006 at Stansted and Luton respectively. Mean aircraft size is consistently low at London City, with only 30 passengers per aircraft in 2006, reflecting this airport's niche market role for mainly serving European business travellers.

Figure 1 also shows the temporary effect of sharp cost increases brought about by two Oil Crises (1973 and 1980-1981), and lowered passenger confidence following the Gulf War (1991) and terrorist attacks of 2001 in depressing demand. These are largely worldwide downturns and do not have a significant impact on the dynamics of the multi-airport system or the general growth trends. The terrorist attacks of 2001 do, however, have a greater effect on airports serving intercontinental traffic (e.g. Heathrow) than the airports serving domestic and intra-European traffic (e.g. Stansted).

Technical Effects

It is clear from Figure 1 that there has been a steady growth in enplanements at Heathrow and Gatwick Airports since the 1950s and 1960s, respectively, and at Luton, Stansted, and City Airports since the 1990s. This growth in demand is, however, becoming constrained by airport capacity. The five airports in London currently operate a total of six runways, with a total capacity of 1.2 million aircraft movements per year [16]. In 2006 this system as a whole was at 87% utilisation. However, utilisation levels differ between the different airports.

In 2004 the growth at Heathrow abruptly stops, while that at Gatwick, Stansted and Luton continues to grow. This suggests that the airport has reached capacity, with no further straightforward capacity expansion possible. Heathrow operates two parallel runways with an imposed capacity of 480,000 movements per year[2], which was utilised to 99% in 2006. Operators thus have a strong incentive to grow operations at other airports in the system. However, this may be balanced out by the need for BA and its alliance partners to maintain a hub at Heathrow with high connectivity for hub-and-spoke operations. 34% of passengers at Heathrow are connecting, whereas the other London airports have less than 15% connecting passengers [16]. This may also contribute to the fact that despite reaching capacity, mean aircraft size has not increased over the last three years at the airport, with aircraft operated on feeder routes remaining relatively small. The result, however, is that the incentive is much stronger for point-to-point carriers (typically low-cost) to base themselves elsewhere. Further growth at Heathrow itself is only likely to come through capacity expansion, which must take place through either infrastructure development, or policy changes, such as abolishment of the Cranford agreement, which limits use of both runways to limit noise impacts. A number of alternatives are currently under investigation [17], including mixed-mode operations (allowing takeoffs and landings in both runways, and requiring adjustment of the Cranford agreement), which could increase capacity to 540,000 movements per year, and a third runway, which could increase capacity to 700,000 movements per year with mixed-mode operations. Each of these alternatives is politically sensitive.

Gatwick is the busiest single runway airport in the world, with a capacity of 280,000 movements per year [18] which was utilised to 94% in 2006. It is clearly less constrained than Heathrow, but has little room for further growth. A second runway, which could increase capacity to 465,000 movements per year has been suggested by the airport authority [18] but was not recommended in the white paper on airport expansion [19].

Stansted, Luton and London City also operate single runways, with relative capacities of 241,000 [19], 240,000 [19] and 73,000 [20] movements per year. Of these, Stansted was utilised to 86% in 2006 with the highest growth in the system and has been recommended for the development of a second runway [19], which would increase its capacity to 510,000 movements per year. Luton was operated at only 48% utilisation in 2006, but is constrained in which types of aircraft can be operated because of limited runway length. Studies are underway to extend or replace the runway at Luton with a longer runway [19]. London City operated just over capacity in 2006. The capacity is an imposed limit, however, to reduce noise, and the runway could handle more than twice this amount of traffic if permitted [20]. London City is also limited by runway length.

Technical constraints are thus a strong factor in the present development of the London system. As Heathrow is at capacity, and Gatwick is likely to reach capacity in the near future, growth must instead come from the third, fourth and fifth airports of the region, or from some hitherto undeveloped airport. Luton airport has the most available capacity for further growth.

[2] The capacity limit at Heathrow was imposed with the opening of the new Terminal 5 [19].

Economic Effects

As discussed above, the development of all London airports is highly influenced by the economic decisions of established carriers operating at the airports and new entrants. The growth of Gatwick and Heathrow in 1980s and 1990s can at least partly be attributed to competition between Virgin Atlantic and BA, while the growth at Luton and Stansted from the late 1980s until the present day can almost completely be attributed to the decision by low-cost carriers to operate there, because of low operating costs. Similarly, much of the growth of London City can be attributed to the development of niche business markets from that airport. These decisions, although linked to capacity constraints, have been primarily driven by economics.

The markets served by each airport also have a significant impact on the types of aircraft operated. The steady growth in aircraft size observed at Heathrow and Gatwick has been enabled by the development of larger aircraft able to fly longer distances, which are particularly important to the service of intercontinental routes, which dominate the traffic at Heathrow and, to a lesser extent, Gatwick (55% of traffic at Heathrow is intercontinental, while 35% is intercontinental at Gatwick). Stansted and Luton serve primarily domestic and intra-European traffic (75% of traffic at Luton is intra-European and is 16% domestic, while at Stansted 82% is intra-European and 12% is domestic). These markets are typically served by small and medium sized aircraft, with the number of medium sized aircraft increasing as the airlines grow, serving destinations further and further from their base. This explains the rapid growth in mean aircraft size at these airports in Figure 1. Because of runway limitations London City is only capable of operating small aircraft types, so the mean aircraft size has instead remained low.

Other economic reasons for secondary airport expansion discussed in Section II include accessibility of new catchment areas and connectivity to the existing catchment area. These factors, although having relatively less importance for the growth of the London multi-airport system, are discussed below.

Passengers will typically prefer to fly from airports which are nearer to where they live, if a flight exists from that airport to their desired destination and all other factors being equal. However, the South East (where Greater London is located) has the greatest population and is the region that generates/receives more passengers at all the London airports. For locations in other regions like East Anglia and East Midlands the importance of closer airports (Stansted and Luton respectively) is greater, with 50% of all East Anglia travellers flying from Stansted, and 49% of all East Midlands passengers flying from Luton [21].

Table 2. Access Mode Split at London Airports [21]

Airport	Access mode					
	Private Car	Hire Car	Taxi	Rail	Bus/Coach	Other
LHR	34,4	2,5	**27,5**	**22,5**	13,1	-
LGW	**48,2**	2,2	14	**29**	6,3	0,3
STN	**47**	3,1	8,8	**23,3**	6,3	1,5
LTN	**52,9**	3	13,7	0,3	**29,8**	0,3
LCY	16,8	1,3	**39,4**	**40,2**	1,6	0,6

The connectivity of each airport, as indicated by the access modes available, is shown in Table 2. In general there is no strong difference in accessibility between the London airports, although London City has only had a direct rail link since 2005 and is in a difficult location to reach by private car, and Luton is accessible by rail only via an interconnecting bus link. This difference in accessibility could be one of the reasons that these airports remain London's least-used, with spare capacity.

Good ground connections are, however, more likely to be built after an airport's usage has begun to increase.

Political-Historical Reasons

The impact of external events (e.g. the Oil Crises, Gulf War and terrorist attacks of 11 September 2001) has been discussed above. For London at least, these factors have had minimal long-lasting effect. Instead, the main political constraint on the London system is the impending decision on whether and where new runways should be built. This arises directly from the capacity limits mentioned above and the result will strongly influence the London system's direction of future growth.

IV. The Case of New York

Metropolitan New York has three primary airports with scheduled commercial operations: John F. Kennedy International (JFK), Newark-Liberty International and LaGuardia; two other airports with some scheduled operations: MacArthur-Islip and Stewart; and multiple other airfields for general aviation or military use including Teterboro, which serves a high volume of business jet traffic. Two of New York's airports are ranked amongst the thirty busiest airports in the world (JFK as the 15th and Newark as the 19th) [7].

Historical Overview

The first airport to be developed in the region was Newark airport, in New Jersey in 1928. LaGuardia airport was built in the north-western part of Long Island – closer to the centre of New York City than Newark – in 1939. LaGuardia was the dominant airport of the region by 1948, most likely because of its closer proximity to the city. The construction of JFK airport, which began operations in 1948, was intended specifically to increase the airport capacity of the region. JFK grew quickly until 1967, passing LaGuardia as the busiest airport in the region in 1958. LaGuardia and Newark showed steady but slower growth.

By 1968 all three airports were considered to be overscheduled, and the FAA issued the "High Density Rule" in order to limit the number of takeoffs and landings at designated "High Density Traffic Airports", including the three major New York airports. This brought a significant reduction in the number of movements at JFK and Newark, and a levelling off of growth at LaGuardia. Airlines responded, however, by increasing aircraft size where possible, preventing similar downturns in enplanements (enplanements continue to grow at Newark and LaGuardia, and level off at JFK). This was enabled by the development of new larger aircraft types, including the Boeing 747 in 1970.

Newark airport sees a sharp growth in traffic from 1981, making it New York's busiest airport by 1986, followed by a sharp reduction in 1987. This was due to the emergence and then bankruptcy of PeopleExpress – a low-cost/no-frills airline. After bankruptcy, PeopleExpress merged with Continental Airlines, which developed Newark as an international hub in the 1990s, growing traffic to once more match JFK in enplanements, whilst dominating the region in movements. In recent years JFK has seen rapid growth, primarily due to jetBlue airlines, a low-cost carrier that started operations in 2000 with JFK as its base.

Timeline

Historical data for the three primary airports with scheduled commercial operations serving New York City are presented in Figure 2 from 1948 to 2006 according to data from the US Bureau of

Transportation Statistics [22,23]. The figure shows the development of passenger traffic and aircraft movements by airport and their percentage distribution across airports. Also shown, as in Figure 1, is the average number of passengers per aircraft, which is an indicator of mean aircraft size.

Figure 2 shows the development of a multi-airport system in New York based around the largely steady growth of passenger demand at all airports. JFK (black diamonds in Figure 2) dominates the system in both passengers and movements during the 1960s and 1970s, at which time Newark (blue squares in Figure 2) and LaGuardia (red triangles in Figure 2) catch up. LaGuardia catches up after a steady growth through the 1960s and 1970s, while Newark does so with a sharp increase in traffic in the early 1980s. As in London, all airports are temporarily affected by the Oil Crises of the 1970s, the Gulf War (1991) and the 2001 terrorist attacks. From the mid 1980s the market share of the three airports remains relatively similar through to 2006, with no airport dominating.

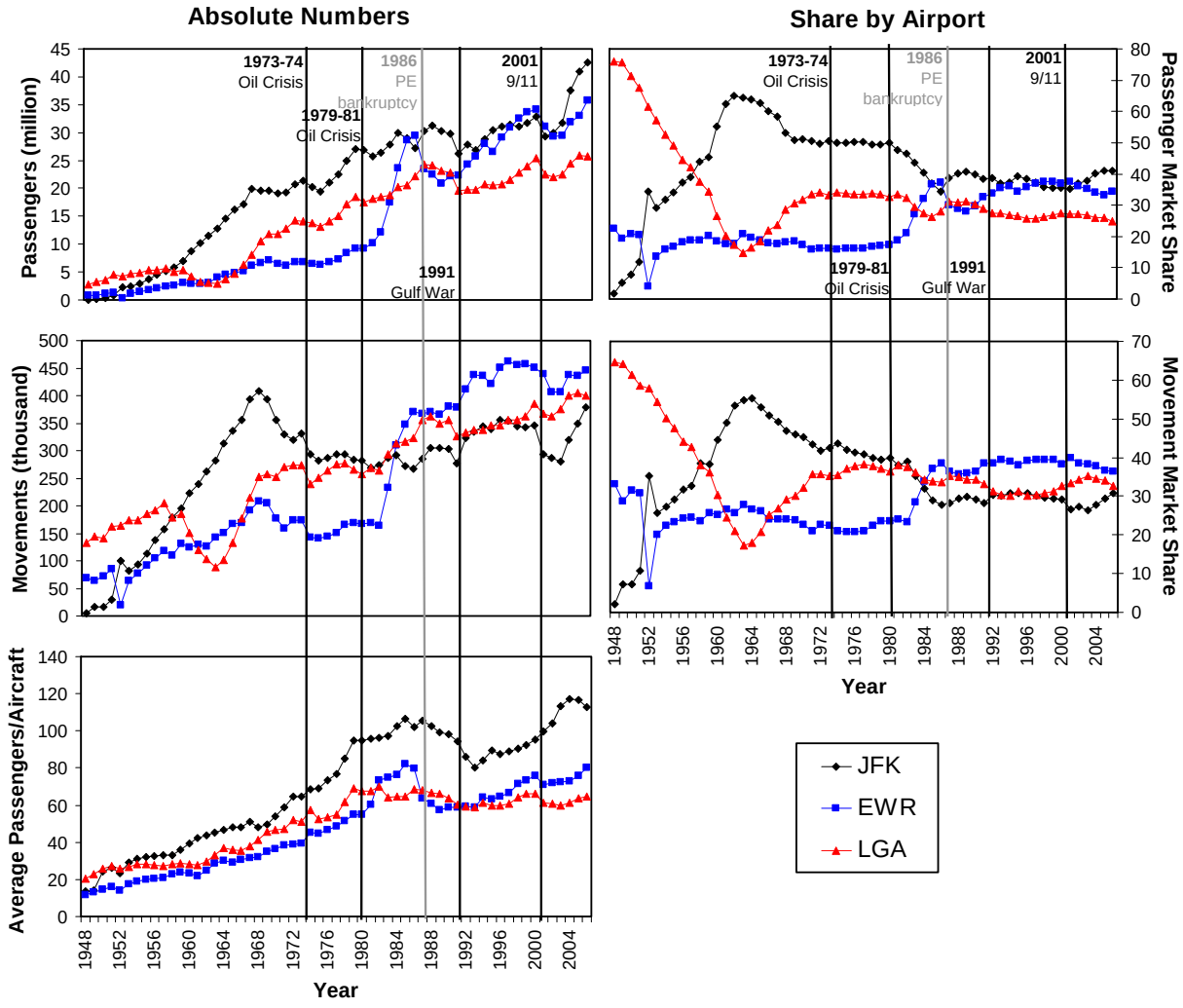

Figure 2. Characteristics of New York City airports, 1948 – 2006 [22,23]

Mean aircraft size, indicated by the plot of average passengers per aircraft in Figure 2, steadily increases at all airports, growing to 113, 80 and 65 passengers per aircraft by 2006 at JFK, Newark and LaGuardia respectively. Aircraft size is consistently greatest at JFK.

Technical Effects

Historically, the effects of capacity limitation in the region can be seen as far back as 1948, when JFK was built to increase capacity in the region, and 1968 when the High Density Rule was introduced at all three primary airports. The three main airports in New York currently operate a total of nine runways with a total capacity of 1.5 million movements per year[3]. Demand on the system in 2006 was 1.2 million movements per year – utilising 82% of capacity. JFK, Newark and LaGuardia operated at 82%, 84% and 80% utilisation respectively [24] in 2006, with capacities of 460,000, 530,000 and 500,000 movements per year and four, three and two runways respectively. New York is thus further from capacity saturation than London, mainly as a result of the increased capacity provided by the greater number of runways available. Unlike London, there are no projects to add more capacity at the main New York airports [25], but there is significant growth at other airports in the region. In 2007 Stewart airport handled around 9,000 commercial flights [26,27], while MacArthur-Islip airport handled over 30,000 commercial operations in 2006 [28]. Current and future New York demand growth is therefore likely to be accommodated by the growth of fourth and fifth airports in the system. This situation is comparable to that in London in the late 1990s.

Economic Effects

As has been described above, the rapid growth of Newark airport in the early 1980s, and the rapid growth of JFK after 2002, can almost exclusively be attributed to the entrance of low cost carriers. This can also be compared to the rapid growth of Stansted and Luton in London in the late 1990s, which was a direct function of the entrance of low cost carriers.

Whilst the major airports have similar fractions of traffic, as discussed above, their primary markets differ somewhat: JFK is the primary international airport of the region, with 50% of traffic being international, whereas Newark serves both international and domestic traffic (31% to 69%), while LaGuardia is primarily a domestic airport (95% domestic, 5% international). The system has thus developed to serve different markets from different airports. New York also has a number of minor airports, including Teterboro airport, which is a centre for business jet traffic. These minor airports are showing rapid growth.

As in London, the markets served by each airport have a significant impact on the types of aircraft operated. Mean aircraft size is consistently greatest at JFK, corresponding to its dominant international traffic, although shows a small drop in recent years corresponding to the growth of jetBlue. Aircraft size also grows at Newark and LaGuardia, with LaGuardia, serving primarily domestic traffic, operating the smallest aircraft by 2006.

Political/Historical Effects

Political effects in New York go as far back as 1939, when LaGuardia airport was constructed at least partly simply to have New York City served by an airport within its boundaries. The impact of external events (e.g. the Oil Crises, Gulf War and terrorist attacks of 11 September 2001) has been discussed above, and, although having greater impact than in London, these factors also appear to have had minimal long-lasting effect. The main political constraint facing the system today is how to limit delays at the primary airports while still allowing competition and growth. A number of congestion management approaches are currently being examined, particularly for LaGuardia [29].

[3] This capacity is calculated as an average between specified airport capacities in optimum and marginal weather conditions from the Airport Capacity Benchmarking Report, 2004 [25].

V. Discussion and Conclusions

The multi-airport system in London was developed from existing minor airports, with no new green-field airports being built to add more capacity. The system is now close to capacity saturation, with the exception of Luton airport, with further capacity expansion most likely to come from increases in capacity at the existing airports, from the use of more distant minor airports to serve London traffic, or from a shift to larger planes to serve more passenger traffic with the same number of movements. The New York system, on the other hand, developed initially through the construction of new green-field airports (LaGuardia and JFK), and later through growth at a less significant airport (Newark). No new airport construction has occurred since, and expansion of the existing airports does not appear likely either, although the system is also close to capacity saturation. Further growth is instead likely to come from development of minor airports in the region, a number of which are available, such as MacArthur-Islip, Stewart and Westchester. The lack of development of new green-field airports in London and New York more recently is a function of both the availability of minor airports for development, and the regulatory difficulties in building green-field airports.[4] There is also the potential for an increase in capacity by the use of larger, less frequent aircraft on major routes. However, airlines compete on frequency and so this option may be considered undesirable.

Despite the differences between the ways in which the London and New York multi-airport systems have grown, some general trends are consistent: Particularly, in both regions different airports serve primarily different markets. In London, Heathrow and Gatwick serve dominate the intercontinental market, while Stansted and Luton dominate the domestic and intra-European market. In New York, JFK and Newark dominate the intercontinental market, while Newark and LaGuardia dominate the domestic market.

The growth of the multi-airport systems examined, however, differs depending on how the secondary airports initially developed. Where an existing minor airport grows to serve a multi-airport system, such as Stansted and Luton in London, and Newark in New York, growth is from low-cost carriers. This is for technical (lower delays) and economic (lower operating costs) reasons, and results in airports that serve primarily the low-cost market. With time these airports may shift to serve a broader range of markets – e.g. Newark serving as an international hub for Continental Airlines, and Stansted starting to operate transcontinental flights. In contrast, a new green-field airport is built primarily for technical (capacity constraints at existing airports) or political reasons, such as LaGuardia and then JFK in New York. Growth at these airports comes from a significant transfer of operations from the previous primary airport (initially Newark to LaGuardia, and then LaGuardia to JFK), serving all markets. The previous primary airport may even change its role to serve only specific markets (LaGuardia now serves domestic routes only).

In conclusion, the development of the multi-airport system is a function of technical, economic, and political/historical effects. These effects impact the way the multi-airport systems initially grow, and how the roles of each airport change over time. For the systems we have discussed in detail, London and New York, the most important of these effects in the present day are technical constraints on capacity and the resulting political decisions on where/whether to add new capacity, and the economic effect of the entry of low-cost carriers into the market and their subsequent growth. These factors reflect the present state of the aviation market and the maturity of both systems. However, in both cities the initial emergence of a multi-airport system was driven by a

[4] In contrast, many of the rapidly developing cities in South and East Asia and the Middle East have a much smaller stock of existing general aviation or military airports available for adaptation, but have a less constrained planning environment in which it is easier to build green-field airports. These regions may thus see more development of new green-field airports than seen in London and New York.

similar mix of factors, in particular political (e.g. for LaGuardia, the desire to have an airport within city limits) and technical (current or perceived future limitations of the existing primary airport) as well as by the availability of minor airports for expansion. London and New York are the world's largest multi-airport systems, and the factors affecting their historical development are likely to also come into play in many of the world's other newly-developing multi-airport systems. As the number of passengers worldwide continues to expand, particularly in countries such as India and China, more of these systems will develop.

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