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Current and future noise impacts of the UK hub airport

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ABSTRACT

Noise is a negative byproduct of aviation operations, the effects of which can have a significant impact on human health and welfare. In this study, we model the present day noise impacts from two London airports: Heathrow and Gatwick. We monetize perceivable and attributable impacts using a willingness to pay for abatement from hedonic pricing studies, and we monetize other health impacts by combining the value of life years lost from mortalities and a cost of illness approach. We find that noise generated by operations at these two airports impacts 255,800 people, contributing to 54 myocardial infarctions and 17 premature mortalities each year. We find annual total damages of £80.3 million and £0.87 million attributable to Heathrow and Gatwick respectively. Further, we calculate expected noise impacts in 2030. Due to capacity constraints and technology improvements, noise impacts are expected to decrease to £76.5 million per annum if neither airport undergoes expansion. However, if Heathrow expands through runway extension or construction of an additional runway, total damages increase £92.5 million or £104.6 million respectively. Expanding Gatwick with a second independent runway results in total annual damages of £78.8 million.

1. Introduction

London's Heathrow Airport (LHR) is a global aviation hub, which today is approaching operating at its full air traffic movement (ATM) capacity. London's Gatwick Airport (LGW) is the second busiest airport in the United Kingdom by passenger movement. Together these airports serve over 75% of passengers of the London airport system. Environmental externalities resulting from aircraft and ground support noise and emissions impact human health and welfare in the airport vicinity. Of these externalities, noise is often the greatest environmental concern for communities living near airports (Durmaz, 2011). Wolfe et al. (2014) calculate that the annual impacts of aircraft noise on residential property values in the US amounts to $100–400 per person near an airport fence line. On a global basis, He et al. (2014) calculate that the capitalized property damages from aircraft noise in 2005 were $23.8 billion.

Aircraft noise has readily perceivable detrimental impacts that impact quality of life and welfare such as annoyance and sleep disturbance (Miedema and Vos, 2007; Miedema, 2007). Depreciation in the market value of residential property can be treated as a proxy for the willingness to pay for abatement of these perceivable and attributable damages (He et al., 2014). Transportation noise may have additional deleterious effects of which residents are not readily aware or that residents do not attribute to the noise environment. A growing body of literature indicates that aircraft noise contributes to short- and long-term non-auditory health impacts. In particular, aircraft noise has been linked to increased rates of hypertension and incidences of myocardial infarction and stroke (Basner et al., 2014). While there is still significant uncertainty about the mechanisms for and the magnitudes of these effects, there is evidence that they are costly to society (Harding et al., 2013).

In this paper, we assess the impact of aircraft noise on the London population resulting from operations at Heathrow and Gatwick airports. We calculate and monetize readily perceivable noise impacts such as annoyance through a model of willingness to pay for noise abatement. Furthermore, we estimate the incidences and associated costs of noise related hypertension, myocardial infarction, and stroke around LHR and LGW.

A report commissioned by Heathrow Airport Limited concluded that the lack of capacity at LHR is costing the UK economy £14 billion per year and that this could rise to £26 billion per year by 2030 in the absence of expansion (HAL, 2012). The issue of hub airport capacity is a major public policy issue in the UK, with

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options having been considered including not increasing capacity, expanding LHR with a third runway, expanding LGW with an additional runway capable of accommodating independent operations or building a replacement hub airport in the Thames Estuary (THA).[1] Historically, aircraft noise has been one of the most important factors in the UK government decision on hub airport expansion (Nwaneri, 1970). This paper assesses the societal impacts of aircraft noise in future years under different expansion scenarios, presenting projections of noise impacts in the year 2030 for LHR, LGW, and a proposed airport in the Thames estuary.

2. Methods

2.1. Noise modelling

We use the Integrated Noise Model (INM) version 7.0d to assess the extent and magnitude of aircraft noise near London's hub airport. INM, which is publically available, has been in use since 1978, and is currently used in more than 65 countries (FAA, 2008). INM uses noise-power-distance (NPD) data to estimate surface-level noise while accounting for operational settings such as operation mode and thrust level as well as environmental factors such as acoustic directivity and local geography. Aircraft noise at the residential level is measured using the A-weighted continuous equivalent sound level (Leq in dBA) for consistency with other analyses of UK airports. A simulation run for this paper using INM and 2010 operational data at Heathrow found that the use of A-weighted Day Night Level (DNL dBA) results in a 3.7% higher noise level than Leq dBA. Where impact dose-response relationships are developed from studies using DNL dBA, noise exposure levels computed in Leq are increased by 3.7%.

LHR is located at 51.47 °N, 0.45 °W and LGW is located at 51.15 °N, 0.19 °W. Existing runways at LHR and LGW are modeled based on airport diagrams (HAL, 2013). LHR and LGW flight paths are modeled per runway corresponding to the noise preferential routes (NPRs). Historical operational data for LHR and LGW are taken by noise class and aircraft type for 2010 (Lee et al., 2011, 2012b). In 2010 there were approximately 460,000 ATMs at Heathrow airport and 241,000 ATMs at Gatwick airport. Where available, existing INM aircraft representations were applied. If existing aircraft were not available in the INM database, the aircraft with the most similar seat capacity and payload-range characteristics in the database was selected. Finally, aircraft are grouped and assigned to arrival and departure flight paths for each runway. For all LHR scenarios an 83:17 modal split of westerly (runways 27L and 27R) and easterly (runways 09L and 09R) operations is used to match LHR in 2010 (Lee et al., 2011). For LGW scenarios a 73:27 modal split of westerly and easterly operations is used to match LGW in 2010 (Lee et al., 2012b).

While INM is widely used internationally, the UK Civil Aviation Authority (CAA) through its Environmental Research and Consultancy Department (ERCD) has developed and maintained the Aircraft Noise Contour model (ANCON) for its own UK airport noise assessments. We therefore compare results of INM and ANCON for LHR in 2011 (Lee et al., 2012a). The INM-estimated Leq >57 dBA noise contour area is 4.6% (10.9 km^2) larger than the ANCON estimate using the 2011 the ERCD report's flight data. Our comparison implies a discrepancy between models of less than 5% and validates the INM for forecasting future UK aviation noise contours. A similar comparison performed by AMEC (AMEC, 2014) found that INM produces smaller noise contours than ANCON for lower noise levels (<57 dBA Leq) and larger contours for higher noise levels, but that contour areas agreed within 10%. Uncertainty in noise dispersion models have been estimated as ±1.46 dBA (95% confidence, total noise uncertainty, ANCON) and ±2 dBA (triangular distribution on contour uncertainty, INM) (White, 2005; Mahashabde et al., 2011).

2.2. Population data

An update of 2001 UK census data provided by CACI is used for the calculation of population noise exposure in 2010. The CACI population database contains data referenced at the postcode level with each postcode having a single coordinate located at the postcode's centroid. The CACI data has been used by the CAA for the ERCD (Environmental Research ad Consultancy Department) reports for noise exposure contours for all airports in the UK, including Heathrow and Gatwick. Population noise exposure is computed using GIS software MapInfo, by exporting output of the INM model and overlaying the population grid with the noise contours for each scenario. Population points are then matched for each contour and summed within the software for each scenario.

2.3. Impact modelling

2.3.1. Perceived impacts

We estimate perceivable damages from aircraft noise such as annoyance and sleep awakenings by calculating the willingness-to-pay for residential noise abatement of the exposed population. A model of willingness-to-pay (WTP) per dBA (DNL) of noise exposure in excess of the ambient noise level is taken from a meta-analysis of airport noise residential hedonic pricing studies relating aircraft noise exposure to property value loss (He et al., 2014). The willingness to pay per (WTP) dBA (DNL) of noise above the ambient noise level is given by $WTP = 45.68 + 0.0109 \times Income + 0.0093 \times$ non-US-dummy $\times$ Income. A non-US-dummy term is equal to 0 if the airport of concern is in the United States and 1 otherwise, reflecting that studies in the UK and continental Europe have indicated a higher willingness-to-pay for abatement. The ambient background noise level is assumed to be 55 dB DNL, consistent with studies in both the US and Europe (Nelson, 2004). Metropolitan per capita income level for London in 2010 is taken from the UK Office of National Statistics. Taking WTP as a proxy for the perceived damages (or "amenity damages") of noise, total capitalized damages are calculated by summing the willingness-to-pay for abatement for all afflicted people, consistent with the methodology of He et al. (2014). Annual damages are developed from the total capitalized noise damages by assuming a 30 year capital lifetime and a discount rate of 3%, consistent with prior assessments of noise costs (Mahashabde et al., 2011).

2.3.2. Health impacts

While the exact relationship between aircraft noise exposure and physical health impacts is still highly uncertain, a growing body of literature suggests that incidences of health endpoints, particularly cardiopulmonary impacts, can be expressed through an exposure-response curve (Babisch, 2008, Basner et al., 2014). We calculate the costs associated with three health endpoints: hypertension (HYT, i.e. high blood pressure), myocardial infarction (MI, i.e. heart attack) and stroke. For each endpoint, the incidences attributable to noise were calculated by taking the UK-wide baseline rate of incidence (by gender and age) for a given endpoint and a relative risk of increased incidence given the level of noise exposure, where the relative risks were developed from a review of the noise literature. The incidences are then separated into mortality and non-mortality incidences using the UK fatality rates for each

[1] See the Airports Commission website https://www.gov.uk/government/organisations/airports-commission.