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Modeling the cost of bird strikes to US civil aircraft

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ABSTRACT

The objective of our analysis is to develop a model of damage costs that arise from collisions between aircraft and birds, based on data drawn from the Federal Aviation Administration National Wildlife Strike Database (NWSD). We develop a two-part model, composed of two separate statistical models, that accounts for the effects of aircraft mass category, engine type, component of the aircraft struck, and the size and number of birds struck. Our results indicate the size of bird, number of birds, and engine ingestions are the largest determinants of strike-related costs. More generally, our result is a model that provides a better understanding of the determinants of damage costs and that can be used to interpolate the substantial amount of missing data on damage costs that currently exists within the NWSD. A more complete accounting of damage costs will allow a better understanding of how damage costs vary geographically and temporally and, thus, enable more efficient allocation of management resources across airports and seasons.

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Introduction

Costs associated with bird–aircraft collisions affect commerce and safety and are widely acknowledged by the aviation community (Blackwell et al., 2009; Dolbeer, 2013). The annual direct costs (aircraft repair costs) associated with bird strikes in the US have been estimated at US$155 million (Dolbeer et al., 2013). This number, however, is likely a substantial underestimate of the magnitude of the problem. A number studies have indicated substantial underreporting of strikes. Dolbeer (2009) estimated that reporting rates at larger airports may approach 40%, and several other studies have suggested reporting rates of less than 20% (Cleary and Dolbeer, 2005; Wright and Dolbeer, 2005). Thus, the true cost of bird strikes in the US is likely substantially higher, especially if indirect costs (e.g. aircraft downtime) are considered. Globally, conservative estimates of the total monetary costs of bird strikes range from US$1.21 to US$1.36 billion annually (Allan and Orosz, 2001). The recognition of the high cost of strikes has led authorities in many developed countries to impose some form of wildlife management requirement on commercial airports (Dolbeer and Wright, 2009; DeVault et al., 2013). Wildlife hazard management regulations in the US (14 Code of Federal Regulations part 139) focus largely on addressing and mitigating wildlife hazards immediately upon detection, regulating land use on or around airports, and conducting wildlife hazard assessments (Cleary and Dolbeer, 2005; FAA, 2007; Blackwell et al., 2009; Dolbeer and Wright, 2009).

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A number of previous studies have analyzed the risks posed by different bird species. Zakrajsek and Bisonette (2005), for example, report that vultures, geese and pelicans are the most hazardous birds to US Air Force aircraft. Dolbeer et al. (2000) presents similar findings and conclude that a better understanding of species-specific risk can guide the allocation of management resources at airports. However, efficient allocation of management resources to mitigate the risk and cost of bird strikes also requires assigning management resources to the airports where the problem is relatively severe. Thus, an accurate understanding of how strike costs vary by airport and over time is beneficial. Unfortunately, fully understanding the geographic and temporal variation in costs is difficult because many reported strikes do not provide cost information. Dolbeer et al. (2013), for example, found that only 16% of reported strikes that indicated an adverse effect reported a damage cost. The estimate of $155 million in annual direct costs accounted for underreporting of damage costs by assuming that reported damage costs were representative of reported strikes that failed to report an estimate of damage costs. While this is a reasonable procedure for estimating damages at a national level, important differences might be missed if applied at an airport level. If the underreporting of costs varies by airport, then assigning a mean damage cost to missing data points is problematic. Some airports will suffer damage costs that are above or below average due to the type and number of aircraft and birds present. Thus, a method of assigning damage costs to strike reports that accounts for the characteristics of the particular strike would be beneficial.

To this end, our objective is to develop a model of damage costs, based on data drawn from the Federal Aviation Administration National Wildlife Strike Database (NWSD). In future analyses, our model will allow estimation and interpolation of strike costs based on certain other characteristics of the strike that have been reported. In addition to its use as an interpolation tool, the model allows the contribution of specific strike characteristics to the cost of the strike to be examined and quantified. In particular, we hypothesize that phase of flight (affecting airspeed and altitude of encounters with birds), aircraft mass, engine type, and component struck would be relevant explanatory variables in a model of strike-related costs.

Our results will be useful for two reasons. First, its use to interpolate missing cost data in the NWSD will provide for a better understanding of how costs vary across airports and over time. This will enable managers to more accurately target airports and seasons with the highest damage costs. Furthermore, it provides a better understanding of the relative contributions of different strike characteristics to the cost of the strike. Such findings are important to understand how vulnerability to strikes varies across aircraft designs and how damage to specific components contributes to costs. The manuscript proceeds by discussing the NWSD and the particular variables that were used in our analysis. Details of the statistical models and estimation procedures are then presented before a detailed discussion of the results. Finally, we offer some concluding remarks regarding the limitations of our analysis and implications of our findings.

Materials and methods

Data

At the time of download, the NWSD included 145,846 reported wildlife strikes from 1990 through 2013. The NWSD reflects only the voluntary reports of wildlife strikes to the FAA from airlines, airports, pilots, and other sources (http://wildlife.faa.gov/). Detailed descriptive statistics regarding the broad dataset are published annually and are publicly available (Dolbeer et al., 2013). The full NWSD contains information on over 90 different variables associated with each strike. Two types of costs are reported in the NWSD: strike-related damage costs and other indirect costs (e.g. flight schedule disruptions, aircraft downtime). However, the indirect costs are reported far less frequently in the NWSD and less is known about the comprehensiveness of existing reports of the indirect costs. Therefore, our focus is limited to modeling direct, strike-related damage costs. It should be noted, however, that some of the reported strike-related damage costs are likely underestimated because they are sometimes reported before the aircraft has been fully evaluated (Dolbeer et al., 2013).

Of the remaining variables in the NWSD, only a subset was appropriate for our analysis. We hypothesize that phase of flight, aircraft mass, engine type, and component struck would be determinants of strike-related costs. We also include measures for the size and numbers of birds involved in a strike. Our research efforts are focused on wildlife strikes between civil and/or commercial aircraft and birds; our analysis excludes strikes with military aircraft and any collision between an aircraft and non-bird wildlife. We focus our attention on those variables which were related to the expected value of damages given that a strike has occurred, and omitted all those variables which are related predominantly to the probability of a strike occurring (e.g. season of year, time of day, geographic region, etc.).[1]

There are also data series that suffer the dual problems of high correlation with other relevant explanatory variables, as well as substantial numbers of missing observations across the NWSD. For example, height and speed are two data series that are relevant, but both are highly correlated with the phase of flight during which the strike occurred. Including both the phase of flight categories as well as the combination of the available height and speed variables would introduce considerable difficulties with inference. In addition, there are tens of thousands of observations for which height and/or speed are unreported, and including these variables in the model would substantially reduce our sample size. In each case where discretion is required regarding including a variable, we opt for the specification which offers the largest possible sample size

[1] It is true that strike costs vary according to region, season, and time. However, costs vary in response to these because the types of birds and aircraft involved in strikes tend to vary by them. Thus, it is preferable to focus on the proximate causes of the variation rather than the indirect causes.