Regulatory Dynamics in U.S. Aviation Safety: Economic Determinants of FAA Behavior

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Abstract

This paper empirically analyzes U.S. Federal Aviation Administration (FAA) behavior. The FAA has been accused of regulatory capture. This paper studies how industry conditions affect regulatory decisions as a potential test of capture against a multi-stakeholder objective function. The analysis uses National Transportation Safety Board recommendations - which are based on independent accident investigations – as plausibly exogenous flow of potential new rules. The results suggest that regulatory activity is stationary and pro-cyclical: A one-standard deviation increase in industry growth increases recommendation adoption odds by a factor of 1.4. The paper identifies additional predictors of FAA decisions (e.g., air crash fatalities).

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1 Introduction

This paper presents an empirical analysis of decision-making by the U.S. Federal Aviation Administration (FAA), an agency whose actions are of special academic and policy interest. On an average day in 2017, more than 2.5 million passengers traveled on air carriers operating in the United States.[1] Aviation safety has been regulated by the U.S. government since the early days of commercial air travel, and there are arguably public interest reasons for doing so. These include information asymmetries due to the limited observability of operator safety levels (Rose, 1992), externalities from accidents posing a risk to other aircraft or life and property on the ground, and the strategic importance of the aerospace industry (Rice, 1990). As the FAA is the primary federal agency in charge of regulating civil aviation in the United States, its decision-making is thus arguably of broad empirical interest.

Both legal scholars (e.g., Niles, 2002; Carlisle, 2001) and public commentators (e.g., Public Citizen, 2001; Nader and Smith, 1994) commonly portray the FAA as having fallen victim to *regulatory capture.* These analyses typically present collections of case studies of FAA decisions. Carlisle (2001) concludes that the FAA is "essentially impotent" and needs to be "completely restructured." While Niles (2002) is careful to note the empirical difficulty of providing conclusive proof of capture, he argues that several cases of FAA behavior "provide strong circumstantial evidence of extensive influence of, if not capture, by [industry]." To the best of my knowledge, however, FAA behavior has not yet been analyzed econometrically in order to quantify some of its key determinants. Going back to McFadden (1975, 1976), discrete choice and related estimation methods of regulatory behavior have been widely used to study bureaucrats' objectives in other settings (e.g., Leaver, 2009; Moore, Maclin, and Kershner, 2001; Ando, 1999; Olson, 1995, 1997, 2000; Cropper, Evans, Berardi, Ducla-Soares, and Portney, 1992; Thomas, 1988; Magat, Krupnick, and Harrington, 1986; Weingast and Moran, 1983). This paper seeks to contribute to this literature by presenting (i) what is to the best of my knowledge a novel such analysis of the FAA, and using the results to (ii) critically evaluate the capture hypothesis.

[1] Bureau of Transportation Statistics Air Carrier Summary Data: *Passengers, All Carriers, All Airports.*

As a theory of regulator behavior, the idea that agencies - though perhaps initially motivated by public interests - over time may become *captured* by the industries they oversee goes back at least to Bernheim (1955). While the regulatory economics literature has formalized capture in various forms (e.g., Laffont and Tirole, 1991), it has also identified institutional design mechanisms that a political principal can use to mitigate regulator collusion with firms. The dynamics of congressional oversight of the FAA arguably match some of these mechanisms. For example, Congress has lowered some of the FAA's discretion over time and introduced separation by transferring some FAA authorities to new agencies,[2] both in line with (dynamic) collusion-proof equilibrium mechanisms in Martimort (1999) and Laffont and Martimort (1999), respectively.

This paper presents an empirical analysis of FAA decisions net of this congressional oversight, focusing specifically on FAA responses to new aviation safety recommendations issued by the National Transportation Safety Board (NTSB). The NTSB is an independent federal agency charged with investigating every civil aviation accident in the U.S., and issuing safety recommendations that would "ensure that such accidents never happen again" (NTSB, 2015), without regard to their potential costs (Holanda, 2009). NTSB recommendations thus constitute a flow of *potential new rules* that the FAA may choose to adopt, increasing regulatory tightness, or reject. Importantly, this flow of potential new rules is plausibly exogenous to economic fluctuations and other covariates of interest, given the NTSB's mandate and the high degree of heterogeneity in the duration of accident investigations. (Of course the analysis addresses endogeneity concerns such as from airline profitability affecting accidents (Rose, 1990)). This paper thus studies how the FAA's proclivity to adopt or reject NTSB safety recommendations is affected by characteristics of recommendations (e.g., number of fatalities in source accident) and the economic environment.

Indeed, a central focus of the analysis is to assess the effect of air transport industry conditions on FAA decisions, as the seminal analysis of the economic theory of regulation (ET) by Peltzman (1976) identified pro-cyclicality in regulatory tightness as a key implication of a model

[2] For example, in the aftermath of the terror attacks of September 11, 2001, Congress transferred some aviation *security* authorities away from the FAA to the newly established Transportation Security Administration.

where the regulator's objective function includes the surpluses of both consumers and industry. That is, this paper studies how FAA decision-making responds to fluctuations in air transport industry conditions as a potential test of capture against a multi-stakeholder FAA objective function. ET models predict that regulators respond to shifts in industry surplus by adjusting rules to maintain the politically optimal distribution of surplus across stakeholders (Peltzman, 1989). In such a setting, "regulation will tend to be more heavily weighted toward 'producer protection' in depressions and toward 'consumer protection' in expansions" (Peltzman, 1976). While Peltzman's analysis focuses on price-entry regulation, the intuition should transfer to the regulation of aviation safety in a competitive market under certain assumptions. Intuitively, aviation safety is an imperfectly observable product attribute (Rose, 1992), or a credence good. While consumer demand for air transport may depend positively on *perceived* safety, the industry profit-maximizing safety level may be inefficiently low compared to the full-information equilibrium (as in, e.g., McCluskey and Loureiro, 2005), especially if market incentives for safety provision are weak (Rose, 1992). Under certain conditions, regulators may thus face a tradeoff where safety mandates in excess of profit-maximizing levels redistribute surplus from industry to consumers on net (see Online Appendix for a model sketch). Consequently, this paper takes the implication of a model with a mixed FAA objective function to be that positive shocks to the air transport industry should lead to a tightening of safety regulations at the margin. In contrast, capture models would predict either a trend in regulatory agency behavior towards a fully captured equilibrium, or a captured continuation equilibrium where the regulator always protects industry. In this setting, regulators would have no direct reason to tighten safety standards in response to, e.g., a beneficial cost shock for producers.[3]

The results suggest that FAA adoption of NTSB safety recommendations appears both (i) stationary over time and (ii) pro-cyclical. In the benchmark specification, a one-standard deviation increase in the real air transport industry growth rate (8.5%) at time $t-1$ is associated

[3]Captured regulators would only tighten rules in response to economic fluctuations is if those shocks altered the profit-maximizing level of safety standards. While this could be the case if, for example, positive income shocks increase the marginal demand benefit of public safety perceptions, the analysis controls for this channel by controlling for aggregate income (GDP) changes.

with an 1.4-fold increase in the adoption odds of safety recommendations issued at time t (the following year), and an increase in the aggregate share of adopted recommendations by $5 - 5.5$ percentage points, against a mean implementation rate of 78% (standard deviation 10%). This pro-cyclicality is consistent with a positive weighting of both consumer and producer interests and thus arguably difficult to reconcile with pure capture or a trend towards such an equilibrium. Of course a number of important caveats apply: capture in a quantitative sense ("too much" weight on producer interests) cannot be rejected, and the analysis speaks only to FAA adoption of NTSB recommendations, whereas other margins - such as regulatory enforcement - may be susceptible to separate capture dynamics.[4] More broadly, the empirical results also associate other factors with FAA decisions. For example, the number of major national U.S. air crash fatalities in a given year appears to significantly increase the FAA's propensity to adopt NTSB safety recommendations issued that year, even controlling for the number of fatalities actually associated with a given recommendation.

These new findings about FAA behavior relate, on the one hand, to the empirical literature on incentives for aviation safety (e.g., Borenstein and Zimmerman, 1988; Mitchell and Maloney, 1989; Rose, 1990, 1992; Bosch, Eckard, and Singal, 1998; Helland and Tabarrok, 2012). To the best of my knowledge, this is the first econometric analysis of the economic determinants of FAA decision-making. The results also relate to prior studies on the effects of economic conditions and other shocks on regulatory activity. The documented positive effect of mortality on public safety decisions echoes the findings of, e.g., Cain and Rotella (2001), who find that waterborne disease outbreaks commonly increased American cities' expenditures on public sanitation in the early 20th Century. On economic conditions, Feinstein (1990) proposes a detection controlled estimation method to study firm violations of occupational safety regulations, and finds that government monitoring of plants may be less strict in areas with higher unemployment rates.

[4] Indeed, in 2008 two whistleblowers alerted Congress that FAA inspectors had been complicit in allowing Southwest Airlines to operate 46 aircraft in known violation of airworthiness rules (HCTI, 2008). Congress responded by implementing a two year 'cooling off' period restricting FAA inspector employment at airlines they previously oversaw, and created an Aviation Safety Whistleblower Investigation Office (Mulligan, 2012), again highlighting the importance of the political principal in fighting capture.

Helland (1998) similarly finds that higher local unemployment is associated with less stringent inspections for Clean Water Act compliance. On the legislative side, Lyon and Yin (2010) find that local unemployment rates are negatively associated with the probability that states adopt renewable portfolio standards. This paper's findings on the pro-cyclicality of regulatory rulemaking thus add to these prior results documenting pro-cyclicality in other margins, such as enforcement.[5]

The paper proceeds as follows. Section 2 describes the institutional background, and Section 3 the data. Section 4 presents the empirical model and results. Section 5 concludes.

2 Background

The United States government has regulated aviation since the early days of commercial air transport. While fatality rates have declined significantly over time, safety remains an evolving target due to changes in the industry and technology (Barnett, 2001). At the forefront of this challenge is the National Transportation Safety Board (NTSB), which investigates every civil aviation accident in the U.S., and conducts safety studies. Although initially a part of the Department of Transportation, in 1974 the NTSB was made independent to safeguard its objectivity (NTSB, 2015). Its central role is to issue safety recommendations based on its investigations and safety studies "with one aim—to ensure that such accidents never happen again" (NTSB, 2015). However, the NTSB is not a regulatory agency; it can only *recommend* actions to agencies with the relevant authority, such as the Federal Aviation Administration (FAA).

The FAA is legally bound to respond to NTSB recommendations, but does not have to adopt them. Indeed, regulatory agencies are usually required to weigh costs and benefits of proposed rules. The precise requirements about whether and what kinds of cost-benefit analyses need to be conducted vary by the type of regulation or action, and have also evolved over time (FAA, 1998). A central difference between the NTSB's and the FAA's perspectives is thus that "the NTSB

[5] Other studies in the legislative realm include López and Ramirez (2004, 2008), who study the impacts of business cycle fluctuations on legislator voting behavior, and, more broadly, Kahn (2007) who evaluates the effects of environmental shocks on congressional representatives' propensity to vote for new environmental legislations.

can make recommendations that represent the ideal safety system without regard to cost, while the FAA must respond to the recommendation based on a legislatively mandated cost/benefit analysis" (Holanda, 2009). Consequently, this paper uses NTSB recommendations as a flow of *potential new rules*, and studies the *fraction* or *probability of recommendations adopted* as measures of the FAA's regulatory stringency over time.

Importantly, I take advantage of the fact that the NTSB grades the FAA's responses to its recommendations. After issuance of a recommendation, the NTSB and FAA enter into a dialogue where the NTSB assigns and updates its grading of FAA responses as, e.g., "Unacceptable" or "Acceptable" until the case is considered "Closed" with a final rating.[6] The agencies' written correspondences about each recommendation are part of the public record. The following describe some examples in each category:

Recs #A-88-123 and #A-88-122: In February 1988, a fire broke out in the cargo compartment of an American Airlines DC-9. While the aircraft landed safely, the NTSB recommended that the FAA require the installation of smoke detection and fire extinguishing equipment in all Class D cargo compartments. While the FAA initially responded that it would consider drafting such a rule, it subsequently conducted a cost-benefits analysis "with the results being cost-to-benefit ratios of 6.2 to 1.0 and 3.5 to 1.0." As a result, the FAA planned "no further action on the recommendation," and the NTSB closed it in 'Unacceptable' status.

Tragically, in May 1996, a ValuJet DC-9 crashed into the Florida Everglades after a fire broke out in its Class D cargo compartment. All 110 passengers and crew perished. In its accident report, the NTSB cited the FAA's "failure (...) to require smoke detection and fire suppression systems" as one of the probable causes of the crash. The FAA ultimately issued a new rulemaking requiring these modifications. Critics commonly cite this case as evidence of the FAA's "apparent priority for promoting the airline industry over safety concerns" (Carlisle, 2001).

Though well-known, this example is not typical in that the FAA usually does not present

[6] In rare cases (17 in the sample), the NTSB graded FAA responses as "Exceeds Recommended Action." Note that I disregard recommendations that have not yet been processed (i.e., status is "Await Response," "Initial Response Received"), or that are "No Longer Applicable," "Superseded," or "Reconsidered."

a formal cost-benefit analysis when rejecting a recommendation. In some cases, the conjecture that costs would not outweigh benefits seems intuitive. For example:

Rec #A-12-048: In response to several incidents of taxiing aircrafts' wingtips colliding with other planes, the NTSB recommended that the FAA "require the installation of anti-collision aid, such as a camera system" on new aircraft. The FAA responded that "the limited safety benefit of a taxi anti-collision system, such as wingtip cameras, does not justify the cost burden of an FAA mandate for their installation."

In other cases, the assumptions rationalizing the FAA's rejection seem less clear. For example:

Rec #A-12-001: In response to crash landings where overhead bins and passenger service units (PSUs) fell onto passengers, the NTSB recommended that the attachments of these units be required to be resistant to higher G-forces. The FAA responded that while "we acknowledge there were head and shoulder injuries attributable to the PSUs (...) these injuries do not justify a change to the existing regulations (...) in the absence of data indicating the PSUs caused fatalities or impeded egress to an extent that would cause fatalities in a post-crash fire."

While the FAA's reasoning focuses on the lack of fatalities associated with falling PSUs, official guidelines instruct the FAA to also value injuries on an abbreviated injury scale proportional to the value of statistical life (VSL). For example, a cerebral concussion with neurological signs should be valued at 0.266 times the VSL (FAA, 2016). The implicit weights and valuations underlying these FAA decisions are thus unobservable, and reflective of the FAA's discretion.[7]

Finally, the following examples illustrate recommendations closed in "Acceptable" status:

Rec #A-10-024: In February 2009, Colgan Air Flight 3407 crashed in Buffalo, New York, killing all 49 passengers and crew. The NTSB determined the probable cause to be the captain's "inappropriate response" to an impending aerodynamic stall, and recommended that the FAA expand flight simulator requirements for stall training. The FAA agreed and followed suit.

Rec #A-13-024: The NTSB investigated a series of near mid-air collisions in 2012 at

[7] While the FAA was historically known for using VSL values "at the low end of the value spectrum" (Viscusi and Gayer, 2002), it now uses \$9.6 million (FAA, 2016). Since 2008, FAA guidance has also added consideration of a positive income elasticity for the VSL. In order to control for pro-cyclicality that could arise based on adjustments in the VSL to aggregate income growth, I thus control for real GDP growth in all specifications.

airports allowing independent take-off and landing operations on perpendicular runways (e.g., Las Vegas McCarran). The NTSB recommended that the FAA require new aircraft separation standards at these airports. The FAA agreed and issued the relevant orders.

Historically, the FAA has adopted most (~80%) NTSB safety recommendations. At the same time, it has also rejected recommendations that the NTSB considers especially important. In order to increase public support, the NTSB began publicizing a "Most Wanted" list of safety issues in 1990. Since 2010, the FAA has been required to report annually to Congress on its responses to safety recommendations.[8] Some FAA decisions may also be discussed in the media, particularly when they relate to high-profile accidents.[9] The public nature of these exchanges highlights the potential for non-industry stakeholders, such as the flying public, safety advocates, and air crash victim family associations, to be politically relevant stakeholders.

3 Data

The main data on NTSB recommendations and FAA responses come from several sources. First, I collect information from the NTSB's *Safety Recommendations Database* yielding 4,276 records on recommendations issued since 1975.[10] Second, I scrape NTSB-FAA correspondence texts from the FAA *Aviation Safety Information Analysis and Sharing* database, and collect data on the source accidents giving rise to each recommendation from the NTSB's *Aviation Accident Database & Synopses*.[11] Together, these data sets provide information on each recommendation's issue date, source accident characteristics, FAA response(s), NTSB ratings of those responses,

[8] The *Airline Safety and Federal Aviation Administration Extension Act of 2010* revised section 1135(e)(1) of Title 49 in the United States Code accordingly.

[9] For example, numerous outlets reported on the fact that many safety recommendations resulting from the US Airways "miracle on the Hudson" water landing had not been adopted by the FAA (e.g., "Safety recommendations unfulfilled 7 years after 'Sully' landed Flight 1549 on Hudson River," Salt Lake Tribune, September 15, 2016). Similarily, in the aftermath of a hot air balloon crash in Texas that killed 16 people in 2016, numerous outlets reported that the NTSB had urged stricter regulation of balloon operators in 2014, but that the FAA had not implemented the relevant recommendations (e.g., "FAA declined to impose more oversight on hot air balloon operators," Los Angeles Times, July 30, 2016).

[10] I use both downloadable data from the current (2018) NTSB website, and more detailed scraped data from a previous version (2013).

[11] Data for 1982-present are on the main database website. Pre-1982 data are available separately at URL: http://app.ntsb.gov/avdata/

closure date, and final status. As a proxy for firms that could be affected by the recommendation, I also conduct a recommendation text search for the names of the 46 main airframe and engine manufacturers tracked in *FAA Aircraft Utilization and Propulsion Reliability Report* data, and manually classify them as domestic or foreign.[12] I also collect aircraft utilization records form the Bureau of Transportation Statistics' *Air Carrier Form 41 Schedule T2* database (1991-2015), aggregate them at the aircraft make-year level, and link this information to both the source accident aircraft and the manufacturers identified in the recommendation text, where available.

Next, aggregate-level explanatory variables of interest are derived from multiple sources. I define "major" U.S. air crash fatalities as those related to major domestic and foreign carriers, air taxies, and commuter airlines (i.e., operating under Parts 121, 135, and 129 of the regulatory code), and obtain accident data in each of these categories from the NTSB's *Aviation Accident Database*. Real annual GDP (chained $2009) is obtained from the Bureau of Economic Analysis (BEA), as is real value added for the air transport industry (NAICS 481, chained $2005, 1977-2011). As an alternative industry measure, I also use the real personal consumption expenditure index for air transportation from the Federal Reserve Economic Data (FRED, 1975-2015). As measures of fuel cost changes, I collect fuel costs as reported by airlines from the trade association *Airlines for America* (converted into real terms through a GDP deflator from the BEA and normalized by the number of departures, also from *Airlines for America*, 1975-2014), and estimates isolating supply-side driven oil price shocks and their cumulative effect on oil prices from Kilian (2009). Table 1 presents both summary statistics and stationarity test results (Dickey-Fuller test p-values).

[12] Manufacturers that were originally U.S. companies who continue to produce and design in the U.S. but were recently acquired by foreign entities remain classified as domestic.

4 Empirical Analysis

4.1 Recommendation-Level Analysis

Following the seminal ideas laid out by McFadden (1975, 1976), I analyze FAA behavior as a discrete choice problem. FAA regulators are assumed to assign each NTSB recommendation j issued at time t expected benefits and costs based on their objective function, which is unobservable to the econometrician. The resulting expected net benefits, $y^{\star}_{jt}$, are thus a latent variable assumed to be a function of covariates X_{jt} and an error ε_{jt} :

$$y^{\star}_{jt} = X'_{jt}\boldsymbol{\beta} + \varepsilon_{jt} \tag{1}$$

The FAA's observable decision y_{jt} is to implement the recommendation if the expected net benefits are positive:

$$y_{jt} = \begin{Bmatrix} 1 \text{ if } y^{\star}_{jt} \geqslant 0 \\ 0 \text{ if } y^{\star}_{jt} < 0 \end{Bmatrix}$$

If the error term in (1) follows the standard logit distribution, the probability that the FAA implements the recommendation is thus given by:

$$\Pr(y_{jt} = 1) = \Pr(Acceptable_{jt} = 1) = \frac{e^{X'_{jt}\boldsymbol{\beta}}}{1 + e^{X'_{jt}\boldsymbol{\beta}}} \tag{2}$$

The key explanatory variables of interest in X'_{jt} include the following. First, as this study seeks to analyze how regulator behavior varies with economic fluctuations, X'_{jt} includes both current and lagged real growth rates of air industry value added and U.S. GDP. The number of lags is set to two based on robustness testing and the Akakie and Bayes Information Criteria for the aggregate time series version of the analysis (see Online Appendix). I focus on growth rates rather than levels to ensure stationarity (see Table 1).

Second, as broader potential determinants of y^{*}_{jt}, the analysis controls for (i) the number of deaths associated with the recommendation's source accident (if applicable), (ii) the aggregate number of major U.S. air crash fatalities in a given year (potentially proxying for salience and public attention towards aviation safety), (iii) the make and utilization rate of the aircraft involved in the recommendation's source accident, and (iv) the nationality (U.S. versus foreign) and utilization rates of aircraft manufacturers mentioned in the recommendation text. An important caveat for these last two variables is that they constitute an extremely noisy proxy for the targeting of a recommendation, since its text may mention certain aircraft but ultimately focus on something else, such as pilot training or runway procedures. For the utilization rates, I construct indicators for the quantile of the aircraft utilization rate distribution (measured by available seat miles) in which the aircraft manufacturer fell in the year of the source accident. The focus on quantiles rather than levels is motivated by the fact that utilization rates are changing over time, so that certain manufacturers may have been relatively dominant in U.S. aviation in the early 1990s, but would appear relatively unimportant when compared to contemporary utilization levels. For analogous reasons, the recommendation text control variables consider utilization quantiles of mentioned aircraft manufacturers at the time the safety recommendation was issued. Finally, as broader controls, (i) all models include a linear time trend, (ii) I consider both a linear shifter and test for regime-switching between Republican and Democratic administrations, and (iii) I control for the volume of NTSB safety recommendations issued in a given year. Since a given accident may give rise to multiple recommendations, standard errors are clustered at the annual level, allowing errors to be correlated across all recommendations issued within a given year.

The central identifying assumption for the main coefficients of interest is that industry conditions are uncorrelated with remaining unobservable factors affecting the likelihood that a recommendations is implemented. This assumption could be violated if, for example, the NTSB issued different types of recommendations based on the state of the economy. However, as described in Section 2, NTSB recommendations are based on accident investigations and studies with the sole purpose of reducing the future likelihood of such accidents. While recommendations should thus be unaffected by cost fluctuations, some endogeneity concerns remain. First, Rose (1990) finds that lower airline profitability is associated with higher accident risk. Consequently, an industry downturn could affect recommendations by increasing accidents. I thus control for the number of recommendations issued each year, and for accident fatalities. Importantly, investigations also vary greatly in required completion time. The mean (median) time lapse between a source accident and corresponding safety recommendation issuance in my sample is 384 (314) days, with a standard deviation of 407 days.[13] Consequently, recommendations issued in year t are based on accidents from a range of previous years. I thus also fail to detect a significant relationship between safety recommendation issuance and either aggregate U.S. accidents or industry growth (see Online Appendix). Of course, the possibility remains that the NTSB adjusts the content of recommendations. In this case, the analysis would measure the *net* effect of economic conditions on recommendation adoption. Another identification concern is that reverse causality could bias the estimated coefficients downwards if (anticipation of future) regulatory activity depresses industry growth. To the extent that this occurs, the results provide a lower bound on the pro-cyclicality of regulatory activity.

4.2 Aggregate-Level Analysis

Analyses of individual-level outcomes as a function of macro-level aggregates can suffer from correlated errors within groups (Moulton, 1990). Clustering standard errors at the annual level may not address this issue sufficiently when the number of groups is small (Donald and Lang, 2007). As an alternative specification, I thus model the aggregate *share* of recommendations issued in year t that receive an "Acceptable" or better response, θ_t :

$$\theta_t = X_t \boldsymbol{\alpha} + \epsilon_t \tag{3}$$

[13] This measure is available for 3,817 of the 3,940 observations. There are 53 observations with negative reported completion times which are set to zero. If these and the 435 observations with zero reported completion times are set to missing instead, the mean (std. dev.) becomes 433 (407) days.

Specification (3) is estimated both via OLS and with a fractional logit model via GLM (Papke and Wooldridge, 1996). As noted above, a unit root can be rejected for the key variables of concern (see Table 1). On the other hand, as Durbin-Watson tests for autocorrelation in the error term yield inconclusive results, I present results with Newey-West standard errors.

4.3 Results

Figure 1 depicts the fraction of recommendations issued in a given year receiving an "Unacceptable" response, along with the lagged air transport industry growth. Two patterns stand out. First, there does not appear to be a clear trend in recommendation rejections over time, in contrast with the notion that the FAA has followed a trend towards capture. While the 'unacceptable' response rate was higher in the post-recession years, by 2013 it had returned to its long-run average of 21%. Second, and equally importantly, the 'unacceptable' response rate appears strikingly inversely related to industry growth, consistent with pro-cyclicality in regulatory decisions. In order to evaluate this association more formally, Table 2 presents the recommendation-level results.

The results confirm a positive and significant association between air transport industry growth and the odds that recommendations are implemented by the FAA. A 1% increase in air industry growth in period $t-1$ is predicted to increase the odds that the FAA will implement recommendations issued in year t by a factor of around 1.04. A one-standard deviation increase in industry growth (8.5%) in period $t-1$ increases the adoption odds by an estimated factor of 1.36-1.39. These results are thus consistent with the idea that FAA behavior is pro-cyclical, in line with the predictions of the economic theory of regulation.

With regards to other determinants of FAA decision-making, the results weakly suggest that major air crash fatalities increase recommendation adoption odds (Column 2), consistent with the possibility that, due to the increasing rarity of fatal air crashes (Rose, 1992), such events cause a salience shock to consumer demand for regulation. While this result is not consistently precisely estimated, it re-appears in the aggregate level analysis (see Table 3). The results also indicate that recommendations are significantly more likely to be implemented if (only) a foreign aircraft frame or part manufacturer is mentioned in the recommendation text. This pattern is visible in the raw data as well. For example, 89% of recommendations mentioning "Airbus" are adopted by the FAA, compared to only 82% of recommendations mentioning "Boeing." Of course, this result is subject to the aforementioned caveat on the noisiness of recommendation text mentions as a measure of recommendation targeting. Another aspect of aircraft makes that may affect adoption incentives is their utilization rate. That is, some aircraft makes are much more widely used and carry many more passengers (e.g., Boeing) than others (e.g., Learjet). The economic theory of regulation suggests that there may be countervailing effects of group size on stakeholders' ability to secure benefits from regulation (Peltzman, 1976). In addition, aircraft with higher utilization rates reflect both larger producers and larger consumer groups, so that countervailing incentives may affect both sides of the regulatory market as utilization rates increase. In line with these mixed effects, the data suggest a weakly U-shaped relationship between aircraft utilization and recommendation adoption rates (see Online Appendix). Finally, the results in Column 3 suggest a significant negative effect of Republican control of the executive branch on the odds that an NTSB recommendation will be adopted; however this effect is not precisely estimated in Column 2. I thus investigate differences between Republican and Democratic administrations more formally in the aggregate-level analysis presented below.

Table 3 presents the aggregate-level results from estimating (3) in a linear and fractional logit model. Pro-cyclicality of regulatory stringency appears robust across all specifications considered: A 1% (one standard-deviation) increase in lagged air transport industry growth is predicted to increase the share of NTSB recommendations adopted by the FAA by 0.6 (5.0 to 5.5) percentage points. For comparison, the mean implementation rate is 78% with a standard deviation of 10%. A one-standard deviation increase lagged in air transport industry growth is thus associated with an increase in the FAA's adoption rate corresponding to half of its standard deviation.

The results further indicate that aggregate major air crash fatalities are associated with a significant increase the fraction of NTSB safety recommendations adopted by the FAA. Based on the linear estimates (Column 2), a one standard deviation increase in major air crash fatalities (+176 deaths) is associated with a 3.4 percentage point increase in the fraction of safety recommendations implemented by the FAA. Finally, while the point estimate on the indicator variable for Republican presidency is negative, the coefficient is not precisely estimated in any of the specifications. In order to explore the possibility that the FAA's objective function may shift during Republican versus Democratic administrations, I conduct a split sample estimation by executive branch party. A Chow test fails to reject the null hypothesis of equal coefficients under Republican and Democratic administrations (see Online Appendix). It should be noted, however, that the small number of observations for Democratic administrations (12 years in the final sample) severely limits the statistical power of this analysis, leaving open the possibility of a true difference that is not statistically discernible.

In order to assess the fit of the fractional logit model, Figure 2 plots the predicted and actual shares of implemented recommendations (based on the full model in Column 4 of Table 3). The model tracks the data with some error, but performs perhaps surprisingly well in predicting fluctuations in adoption.

To summarize, the main result documented in this section is that the FAA's propensity to adopt new NTSB safety recommendations appears both stationary and pro-cyclical. These results are consistent with a model of regulators as having both industry and consumer surplus in their objective function, and re-distributing in response to industry fluctuations (Peltzman, 1976). In contrast, these results are arguably difficult to reconcile with a trend towards capture or a model of pure capture, which would not predict a re-distribution towards consumer safety in response to industry growth. The next Section explores the robustness of these results.

5 Robustness and Extensions

5.1 Timing

So far the analysis has focused on economic conditions in the recommendation *issue* year, rather than the *closure* year.[14] Closure is at the NTSB's discretion and may not reflect a contemporaneous FAA decision, especially for recommendations in "Unacceptable" status, as their closure takes 37% longer on average, and occurs only when the NTSB "concludes that further correspondence on, or discussion of, the matter would not change the recipient's position" (NTSB, 2016). In some cases, closure occurs well after the FAA disagreed with a recommendation. In other cases, however, a recommendation's status may change over time. As the median (mean) closure time is 2 years (3 years), this raises questions about the appropriate timing of the analysis.

I address this concern as follows. First, Table 4 repeats specification (2) only for recommendations that were closed within one year of issuance. The estimated effect of lagged industry growth *increases* considerably in this sample, consistent with a reduction in measurement error in the impact of industry conditions on FAA decisions. A one standard deviation increase in industry growth at $t-1$ increases the odds that an NTSB safety recommendation issued at t will be adopted by the FAA by a factor of 2.0-2.3.

As a second robustness check, I extract NTSB ratings of the FAA's *initial* response letter from correspondence texts, and repeat the aggregate analysis at the *initial response-year* level. Even though the text extraction measures initial ratings with some error (as the NTSB may refer to multiple recommendations in a letter), lagged industry growth is again estimated to significantly increase the fraction of recommendations receiving a positive initial FAA response (see Online Appendix).

[14] The main analysis also includes recommendations that are still in "Open" (acceptable or unacceptable) status.

5.2 Alternative Measures of Industry Conditions

First, as jet fuel constitutes an important cost factor for aircraft operations, international oil price fluctuations provide potentially useful variation in industry surplus. There are, however, several challenges inherent in identifying their effects in the present setting. For airlines, the marginal effect of an oil price increase on operating costs has changed over time due to both increases in aircraft fuel economy and the development of financial hedging instruments (see, e.g., Carter, Rogers, and Simkins, 2006). For the industry as a whole, there are moreover offsetting effects, as higher fuel prices spur orders for new, fuel efficient aircraft and engines, benefiting manufacturers (GAO, 2014). If the FAA places positive weight on both airlines' and manufacturers' respective surpluses, the redistributional incentives from oil price increases may thus be mixed. Finally, econometrically, oil price movements are both well-known to follow a unit root process, and are endogenous to global demand shocks, complicating causal inference.

Table 5 thus begins by presenting 'naive' estimates replacing air transport industry growth in the aggregate analysis (Table 3) with real fuel costs - normalized per aircraft departure - as reported by major U.S. airlines.[15] I present different lag lengths as both the AIC and BIC suggest zero lags to be the preferred specification for these variables. All regressions include the full set of controls from Column 2 in Table 3, but some coefficients are omitted for legibility. Taken at face value, the results in the preferred specification (Column 1) suggest a negative economically and statistically significant association between fuel costs and the recommendation adoption rate. However, this association may well be spurious as a unit root cannot be rejected for the fuel cost variable. Focusing instead on the year-to-year change in real fuel costs - a stationary variable - yields noisy results. Finally, I also experiment with supply-side shock measures developed by Kilian (2009). His analysis decomposes global oil price changes into supply shocks (e.g., reductions in production due to political unrest in oil-exporting countries), oil-specific demand shocks, and aggregate demand shocks. Columns 4 and 5 replace the fuel cost variable with Killian's (2009) estimates of the structural oil supply shocks and their cumulative impact on

[15] Using real crude oil prices and differences instead of airlines' reported fuel costs yields similar results.

global oil prices, respectively. Taken at face value, the results suggest that supply-shock induced cumulative increases in global oil prices are associated with a marginally significant decline in the FAA's propensity to adopt new safety recommendations (Column 5). However, a unit root in this variable can only be rejected with a p-value of 0.16 (see Table 1). The stationary structural residual variable moreover again yields noisy results (Column 4). Overall, the results for oil price shocks are thus statistically inconclusive, but potentially consistent with a negative effect of fuel cost increases on regulatory stringency. Supplementary explorations of other airline industry measures such as operating margins and total employment raise both similar and additional issues, leading to imprecise results (see Online Appendix).

Next, I consider real household consumption expenditures on air transportation measured by a chain-type quantity index. The levels of this series are not stationary as they are trending upwards over time. The year-to-year change (first difference) in the household expenditure index is, however, stationary (see Table 1). Figure 3 plots the analog of Figure 1 replacing growth in industry value added with the change in household expenditures. The series again appears inversely related to the FAA's acceptance rate. In order to evaluate this relationship formally, Table 6 displays the results of both linear and fractional Logit aggregate-level regression results replacing industry growth with changes in the household expenditure index. The results again suggest a pro-cyclicality of regulatory stringency: a one unit (standard deviation) increase in the air transport expenditure index in year $t-1$ is associated with a 0.8-0.9% (4.5%) percentage point increase in the fraction of safety recommendations issued in year t that are subsequently adopted by the FAA.

6 Conclusion

This paper presents what is to the best of my knowledge a first econometric analysis of the FAA in the tradition of discrete choice models of regulator behavior (e.g., McFadden, 1975, 1976; Leaver, 2009; Moore, Maclin, and Kershner, 2001; Ando, 1999; Olson, 1995, 1997, 2000;

Cropper, Evans, Berardi, Ducla-Soares, and Portney, 1992; Thomas, 1988; Magat, Krupnick, and Harrington, 1986; Weingast and Moran, 1983). The FAA as an agency, and incentives for aviation safety more broadly, are arguably of wide public, policy, and academic interest (Borenstein and Zimmerman, 1988; Mitchell and Maloney, 1989; Rose, 1990, 1992; Bosch, Eckard, and Singal, 1998; Helland and Tabarrok, 2012). While the FAA has been repeatedly accused of having fallen victim to *regulatory capture,* congressional oversight of the agency qualitatively matches some of the mechanisms identified by the new regulatory economics literature as useful in avoiding collusion equilibria, such as decreasing agency discretion over time (Martimort, 1999). The extent to which these efforts have been successful arguably remains an open question.

In order to empirically identify the effect of covariates of interest on FAA behavior, this paper takes advantage of the fact that the National Transportation Safety Board (NTSB) - an independent federal agency - issues safety recommendations to the FAA based on accident and incident investigations, and without regard to cost, to derive a plausibly exogenous flow measure of potential new regulations. The analysis then focuses on the effect of explanatory variables on the FAA's propensity to adopt or reject NTSB safety recommendations. First, the results indicate that the FAA's recommendation acceptance rate has remained stationary over time, a finding which is difficult to reconcile with a trend towards a captured equilibrium. In addition, among a number of explanatory variables, the most robustly significant predictor of fluctuations in the FAA's recommendation acceptance rate is lagged air transport industry growth. A one-standard deviation increase in the air transport industry growth rate is associated with an increase in the adoption odds (aggregate adoption share) of subsequently issued safety recommendations by a factor of 1.4 (by 5 percentage points, against a mean of 78% with a standard deviation of 10%). While an increase in regulatory tightness in response to positive industry shocks is difficult to reconcile with pure capture, it precisely matches the predictions of economic theory of regulation models, where the regulator's objective function includes the surpluses of both industry and consumers, and re-distributes surplus based on marginal (political) cost-benefit calculations after cost or demand shocks (Peltzman, 1976). The analysis also finds that a one-standard deviation increase in major air crash fatalities (+176 deaths) is associated with a 3.4 percentage point increase in the fraction of safety recommendations implemented by the FAA. While the analysis is subject to many caveats, the results suggest that the U.S. aviation safety regulatory system as whole has maintained some level of balance between competing concerns. The magnitude of the implicit weights placed on different stakeholders, and the precise role played by different elements of the institutional arrangements between Congress and the FAA, remain interesting questions for future research.

7 Figures and Tables

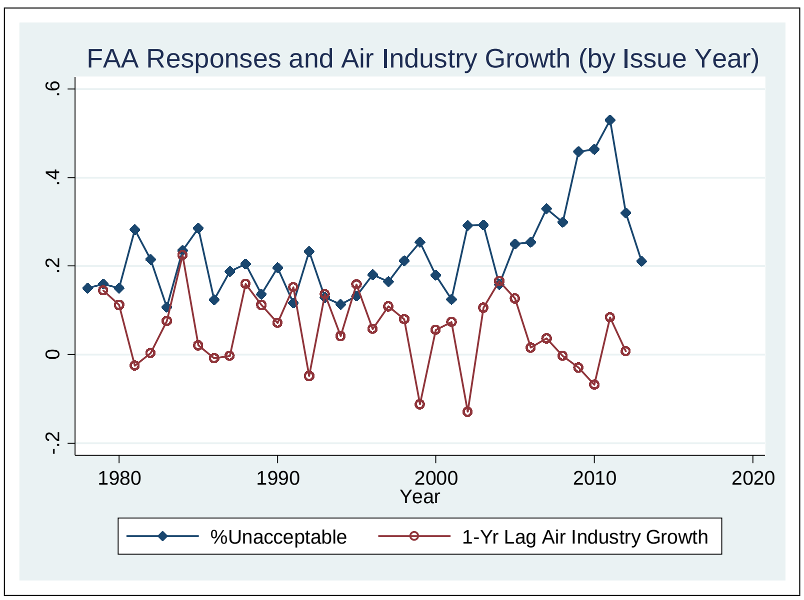

Figure 1

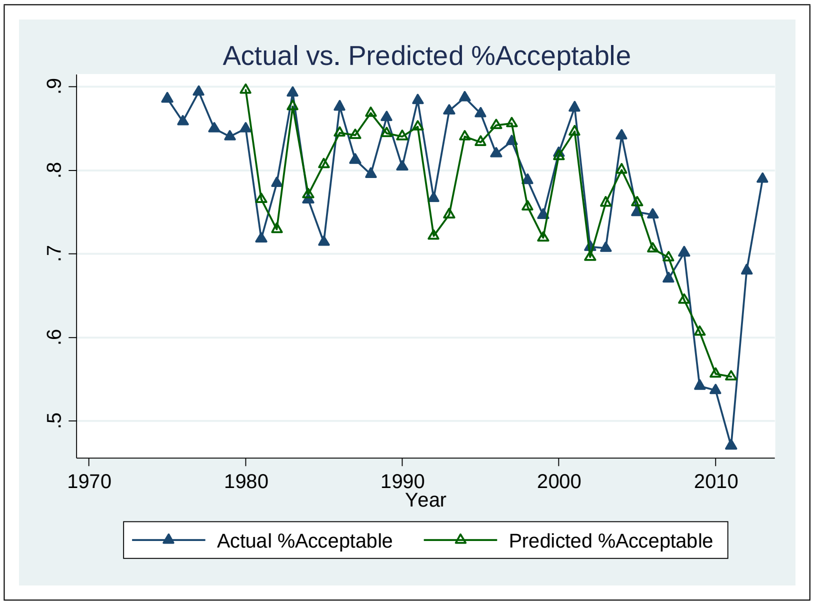

Figure 2

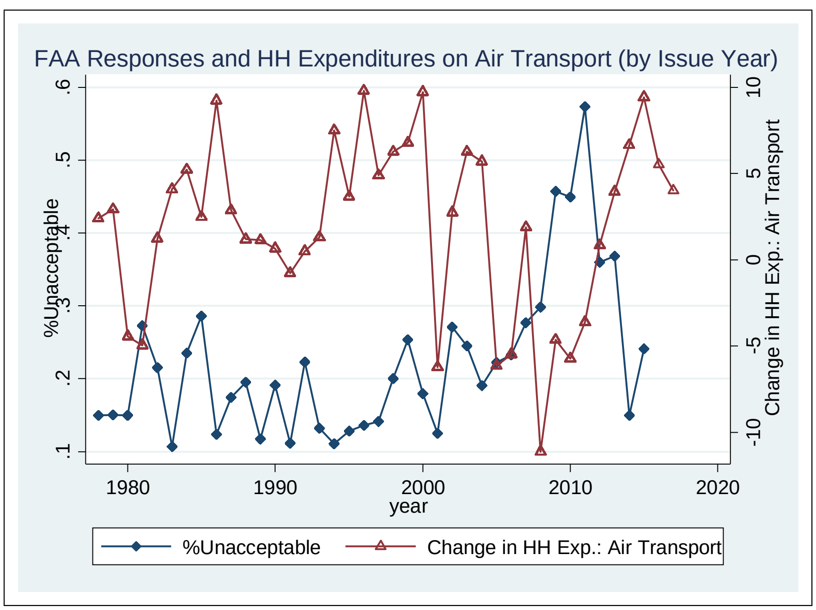

Figure 3

Table 1: Summary Statistics and Stationarity Tests

Variable	Mean	Median	Std.Dev.	Min.	Max.	Obs.	Dickey-Fuller P-Vals., Trend: No	Yes
Acceptable FAA Response (=1)	0.80	1	0.40	0	1	3,981		
Source Accident Fatalities	15.6	1	41.1	0	265	2,710		
Foreign Firm in Rec. Text (=1)	0.03	0	0.18	0	1	3,975		
Air Transport Ind. Growth$_t$	5.6%	6.4%	8.3%			34	0.00	0.00
Real GDP Growth$_t$	2.8%	3.3%	2.1%	-2.8%	7.3%	38	0.00	0.00
Recs. Accepted$_t$	78.5%	80.9%	10.6%	42.6%	89.4%	41	0.04	0.03
Recs. Issued$_t$	97	105	37	19	181	41	0.01	0.00
Total Major Accident Fatalities$_t$	188	137	176	9	801	39	0.00	0.00
Republican$_t$ (=1)	.56	1	.50	0	1	41	0.17	0.36
Fuel Costs/Departures$_t$	2.5	2.1	1.0	1.2	4.3	38	0.59	0.85
Supply-Shock Residual (%)$_t$	-0.00	-0.02	0.24	-0.66	0.38	33	0.00	0.00
Supply-Shock cum. ΔOil Price$_t$	-0.20	-0.29	6.03	-12.45	12.21	34	0.16	0.32
ΔHH Expenditure: Air Transp.$_t$	1.83	2.48	5.01	-11.13	9.79	40	0.00	0.02

Table 2: Recommendation-Level Results

Dependent Variable: Indicator for "Acceptable" FAA Response to NTSB Rec. (=1)			
	(1)	(2)	(3)
	Odds Ratio	Odds Ratio	Odds Ratio
Air Trans. Industry Growth$_t$	1.019**	1.017**	1.013**
	(0.0095)	(0.0072)	(0.0068)
Air Trans. Industry Growth$_{t-1}$	1.037***	1.039***	1.038***
	(0.0010)	(0.0088)	(0.0096)
Air Trans. Industry Growth$_{t-2}$	0.997	0.997	1.014
	(0.00861)	(0.00854)	(0.0123)
Real GDP Growth$_t$	0.990	0.999	0.989
	(0.0279)	(0.0280)	(0.0226)
Real GDP Growth$_{t-1}$	1.002	0.973	0.949
	(0.0402)	(0.0386)	(0.0383)
Real GDP Growth$_{t-2}$	1.153***	1.133***	1.125***
	(0.0416)	(0.0390)	(0.0410)
Source Acc. #Fatalities			1.002
			(0.0014)
Foreign Firm in Rec. Text			3.018**
			(1.527)
Total #Recs Issued$_t$		0.999	0.996
		(0.0025)	(0.0027)
Total Major Acc. Fatals.$_t$		1.001**	1.001
		(0.0005)	(0.0004)
Total Major Acc. Fatals.$_{t-1}$		1.000	1.000
		(0.0005)	(0.0005)
Republican President$_t$		0.857	0.698**
		(0.149)	(0.119)
Year	0.982***	0.982*	0.964***
	(0.0062)	(0.0097)	(0.0100)
Observations	3,427	3,427	2,397
S.E. Cluster	Year	Year	Year
Log-Likelihood	-1738	-1734	-1194
Wald χ^2(df); p-value	75.0(7),0.00	105.8(11),0.00	193.3(13),0.00

Table presents Logit estimation results for regression of indicator that a rec. issued in year t received an "Acceptable" FAA response on the indicated controls and a constant. Robust SEs in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 3 : Aggregate Level Results

Dependent Variable: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response				
	(1)	(2)	(3)	(4)
	%Accpt.	%Accpt.	%Accpt.	%Accpt.
	OLS	OLS	GLM (mfx)	GLM (mfx)
Air Transp. Industry Growth$_t$	0.003	0.003*	0.0025*	0.0024**
	(0.002)	(0.001)	(0.0015)	(0.0011)
Air Transp. Industry Growth$_{t-1}$	0.006***	0.006***	0.0059***	0.0065***
	(0.001)	(0.001)	(0.0014)	(0.0012)
Air Transp. Industry Growth$_{t-2}$	-0.000	-0.000	-0.0004	-0.0001
	(0.001)	(0.001)	(0.0013)	(0.0012)
Real GDP Growth$_t$	0.001	0.002	-0.0004	0.0008
	(0.006)	(0.006)	(0.0049)	(0.0049)
Real GDP Growth$_{t-1}$	0.000	-0.004	-0.0019	-0.0067
	(0.009)	(0.009)	(0.0068)	(0.0067)
Real GDP Growth$_{t-2}$	0.028***	0.024**	0.0270***	0.0234***
	(0.009)	(0.009)	(0.0058)	(0.0056)
# Recs. Issued$_t$		-0.000		-0.0002
		(0.000)		(0.0004)
Total Major Acc. Fatalities$_t$		0.000**		0.0002**
		(0.000)		(0.0001)
Total Major Acc. Fatalities$_{t-1}$		0.000		0.0001
		(0.000)		(0.0001)
Republican President$_t$		-0.007		-0.0168
		(0.034)		(0.0252)
Year	-0.003***	-0.003	-0.0034***	-0.0028*
	(0.001)	(0.002)	(0.0011)	(0.0015)
Observations	32	32	32	32
Standard Errors:	Newey-West	Newey-West	Robust	Robust

Table presents results for OLS (Cols 1-2) and fractional Logit (Cols 3-4) regression of the fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on the indicated control variables plus a constant. Newey-West (Cols 1-3) or robust (Cols 3-4) standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 4: Recommendation-Level Results for Closure Time < 1 Year

Dependent Variable: Indicator for "Acceptable" FAA Response to NTSB Rec. (=1)			
	(1)	(2)	(3)
	Odds Ratio	Odds Ratio	Odds Ratio
Air Trans. Industry Growth$_t$	0.981	0.959	0.956
	(0.0305)	(0.0368)	(0.0414)
Air Trans. Industry Growth$_{t-1}$	1.088***	1.110***	1.100*
	(0.0299)	(0.0429)	(0.0542)
Air Trans. Industry Growth$_{t-2}$	1.024	1.046*	1.041
	(0.0249)	(0.0257)	(0.0296)
Real GDP Growth$_t$	0.966	0.972	1.131
	(0.0997)	(0.117)	(0.163)
Real GDP Growth$_{t-1}$	0.970	0.825	0.887
	(0.0866)	(0.112)	(0.154)
Real GDP Growth$_{t-2}$	1.220*	1.087	0.970
	(0.142)	(0.159)	(0.142)
Source Acc. #Fatalities			1.004
			(0.00793)
Foreign Firm in Rec. Text			2.288
			(2.121)
Total #Recs Issued$_t$		1.005	1.006
		(0.00312)	(0.00370)
Total Major Acc. Fatals.$_t$		1.004*	1.005*
		(0.00252)	(0.00280)
Total Major Acc. Fatals.$_{t-1}$		0.985	0.986
		(0.00961)	(0.0106)
Republican President$_t$		0.437	0.690
		(0.260)	(0.518)
Year	0.974	0.959	0.968
	(0.0252)	(0.0402)	(0.0476)
Observations	668	668	494
S.E. Cluster	Year	Year	Year
Log-Likelihood	-179.2	-173.7	-131.1
Wald χ^2(df); p-value	22.02(7),0.00	29.62(11),0.00	44.67(13),0.00

Table presents Logit estimation results for regression of indicator that rec. issued in year t received "Acceptable" FAA response on the indicated controls and a constant. Sample restricted to recs. that were 'closed' within one year of being issued. Robust SEs in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

Table 5 : Robustness: Fuel Costs and Oil Prices (Linear Aggregate Model)

Dependent Variable: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response					
	(1)	(2)	(3)	(4)	(5)
	%Accpt.	%Accpt.	%Accpt.	%Accpt.	%Accpt.
Fuel Costs/Departures$_t$	-0.0536***	-0.0215	-0.0168		
	(0.0164)	(0.0241)	(0.0233)		
Fuel Costs/Departures$_{t-1}$		-0.0473*	-0.0207		
		(0.0271)	(0.0330)		
Fuel Costs/Departures$_{t-2}$			-0.0346		
			(0.0289)		
Supply-Shock Residual(%)$_t$				0.0451	
				(0.0421)	
Supply-Shock cum. ΔOil Price$_t$					-0.0035*
					(0.0019)
Real GDP Growth$_t$	-0.0007	-0.0041	0.0018	-0.0051	-0.0043
	(0.0074)	(0.0076)	(0.0081)	(0.0054)	(0.0055)
Real GDP Growth$_{t-1}$		-0.0005	-0.0062		
		(0.0077)	(0.0080)		
Real GDP Growth$_{t-2}$			0.0107		
			(0.0079)		
Observations	36	35	34	33	34
R-squared	0.6182	0.6584	0.7177	0.3291	0.4205
AIC	-78.22	-75.62	-74.83	-92.96	-98.09
BIC	-65.55	-60.07	-56.51	-80.99	-85.88

Table presents results for OLS regression of the fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on the indicated control variables plus controls for the total # recs issued in year t, major U.S. air crash fatalities in years t and $t-1$, an indicator for Republican presidency at t, a linear time trend, and a constant. Significance levels are robust to Newey-West standard errors (not shown). (*** p<0.01, ** p<0.05, * p<0.1).

Table 6 : Aggregate Level Results: ΔHousehold Expenditures on Air Transport

Dependent Variable: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response				
	(1)	(2)	(3)	(4)
	%Accpt.	%Accpt.	%Accpt.	%Accpt.
	OLS	OLS	GLM (mfx)	GLM (mfx)
ΔHH Expenditure: Air Transp.$_t$	0.005	0.005**	0.0040*	0.0045**
	(0.003)	(0.002)	(0.0021)	(0.0018)
ΔHH Expenditure: Air Transp.$_{t-1}$	0.009***	0.009***	0.0082***	0.0078***
	(0.003)	(0.003)	(0.0027)	(0.0025)
ΔHH Expenditure: Air Transp.$_{t-2}$	0.001	0.001	0.0009	0.0008
	(0.002)	(0.002)	(0.0017)	(0.0017)
Real GDP Growth$_t$	-0.006	-0.005	-0.0055	-0.0049
	(0.007)	(0.006)	(0.0057)	(0.0054)
Real GDP Growth$_{t-1}$	-0.006	-0.006	-0.0055	-0.0060
	(0.008)	(0.009)	(0.0069)	(0.0073)
Real GDP Growth$_{t-2}$	0.009	0.009	0.0095*	0.0087
	(0.008)	(0.008)	(0.0055)	(0.0057)
# Recs. Issued$_t$		0.000		0.0001
		(0.000)		(0.0003)
Total Major Accident Fatalities$_t$		0.000		0.0001
		(0.000)		(0.0001)
Total Major Accident Fatalities$_{t-1}$		0.000		0.0000
		(0.000)		(0.0001)
Republican President$_t$		0.038		0.0284
		(0.031)		(0.0207)
Year	-0.004***	-0.003**	-0.0040***	-0.0028**
	(0.001)	(0.001)	(0.0007)	(0.0012)
Observations	38	38	38	38
Standard Error Adjustments:	Newey-West	Newey-West	Robust	Robust

Table presents results for OLS (Cols 1-2) and fractional Logit (Cols 3-4) regression of the fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on the indicated control variables plus a constant. Newey-West (Cols 1-3) or robust (Cols 3-4) standard errors in parentheses (*** $p<0.01$, ** $p<0.05$, * $p<0.1$).

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