Online Appendix for:

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

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Contents

1 ET Intuition for Safety Regulation

In Peltzman (1976), the polician's and, by extension, the regulator's objective is to maximize a majority-generating function which depends, informally speaking, on how the surplus is distributed between affected parties. He focuses on a price-entry regulation where $M = M(p, \pi)$ depends on the price of a good p and producer wealth π, with $M_p < 0$ (due to the negative effect on consumers) and $M_\pi > 0$ (due to the positive effect on producers). Profits π, in turn, depend on prices and on costs c with $\pi = f(p, c)$. One of the core insights of the model is that a majority-maximizing regulator would not want to set prices at the profit-maximizing level as he balances political support from increased industry profits against the political costs of consumer opposition to high prices:

$$-M_p \frac{\partial \pi}{\partial p} = M_\pi$$

In the current setting, price and quantity of air travel are determined by the free market, and the regulator's choice variable is a minimum safety level s. Safety is costly to provide, increasing airlines' production costs, ceteris paribus. At the same time, consumer demand for air transport may depend positively on *perceived* safety $\widetilde{s}(s)$ (see, e.g., Borenstein and Zimmerman, 1988). Actual safety s is generally considered an imperfectly observable product attribute (Rose, 1992), or a credence good. On the one hand, a positive *level* of safety standards is thus not necessarily at odds with regulatory capture. On the other hand, however, the privately profit-maximizing safety level s^M may be inefficiently low compared to a full-information equilibrium (as in, e.g., McCluskey and Loureiro, 2005), especially if market incentives for safety provision are weak (Rose, 1992). The central implication is that, over some range of the parameter space, the regulator may thus face a tradeoff analogous to price-setting in Peltzman (1976) where safety mandates in excess of the profit-maximizing level ($s^* > s^M$) redistribute surplus from industry to consumers (on net). That is, if the majority-generating function $M = M(\Omega, \pi)$ depends on consumer surplus $\Omega(p(\widetilde{s}(s), s), Q(\widetilde{s}(s), s), \widetilde{s}(s))$ (where $Q(.)$ denotes equilibrium quantities) and producer profits $\pi = f(p(\widetilde{s}(s), s), Q(\widetilde{s}(s), s), s)$, then the ET-regulator's first-order condition in maximizing M over choice of s yields:

$$M_\Omega \frac{d\Omega}{ds} = -M_\pi \frac{d\pi}{ds} \tag{1}$$

Analogous to the setting with price-entry regulation, (1) showcases that the politically optimal safety level deviates from the profit-maximizing level (defined by $\frac{d\pi(s^M)}{ds} = 0$) as long as consumer surplus can be increased through higher aviation safety at the margin at s^M, as would arguably be expected from the literature on credence goods, and as long as consumers constitute a politically active constituency (i.e., $M_\Omega \neq 0$). Over the area of the parameter space of interest, regulators are thus assumed to be able to redistribute surplus to consumers by increasing safety standards (with $s^* > s^M$).

2 Lag Selection and Robustness

The following table compares results and Akaike/Bayes Information Criteria (AIC/BIC) across competing lag specifications for the benchmark time series model (Eqn. 3). Note that industry and GDP growth controls are always included in tandem so as to maintain the desired ceteris paribus interpretation on the coefficients of interest. The results indicate that the inclusion of two lags minimizes both the AIC and the BIC values (Column 3).

Table A1 : Lag Selection and Robustness

Dependent Variable: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response					
	(1)	(2)	**(3)**	(4)	(5)
	%Accpt.	%Accpt.	**%Accpt.**	%Accpt.	%Accpt.
Air Transp. Industry Growth$_t$	0.000197	0.00139	0.00256	0.00288	0.00303
	(0.00202)	(0.00208)	(0.00184)	(0.00191)	(0.00219)
Air Transp. Industry Growth$_{t-1}$		0.00410**	0.00648***	0.00731***	0.00710***
		(0.00195)	(0.00178)	(0.00194)	(0.00193)
Air Transp. Industry Growth$_{t-2}$			-7.67e-05	0.00128	0.00273
			(0.00170)	(0.00205)	(0.00217)
Air Transp. Industry Growth$_{t-3}$				0.000115	-0.000151
				(0.00211)	(0.00233)
Air Transp. Industry Growth$_{t-4}$					0.00329
					(0.00213)
Real GDP Growth$_t$	0.00902	0.00471	0.00210	-0.00382	-0.00598
	(0.00820)	(0.00856)	(0.00749)	(0.00921)	(0.0101)
Real GDP Growth$_{t-1}$		0.00369	-0.00399	-0.00511	-0.00339
		(0.00949)	(0.00837)	(0.00928)	(0.0106)
Real GDP Growth$_{t-2}$			0.0242***	0.0251**	0.0193*
			(0.00830)	(0.00915)	(0.00977)
Real GDP Growth$_{t-3}$				0.00489	0.00683
				(0.00886)	(0.00946)
Real GDP Growth$_{t-4}$					-0.00496
					(0.00944)
Observations	34	33	32	31	30
AIC	-63.32	-65.28	**-73.34**	-69.23	-67.88
BIC	-51.11	-50.32	**-55.75**	-49.15	-45.46

Table presents linear regression results for fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on the contemp. (year t) and lagged (year $t-j$) real air transport industry and GDP growth rates. All regressions also control for total # recommendations issued in t, number of fatalities in major commercial accidents in years t and $t-1$, a linear time trend, a Republican President indicator, and a constant. Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1).

It should be noted that the relative AIC/BIC values across lag lengths differ for the non-linear models. On the one hand, for the aggregate fractional logit model, the AIC/BIC values appear minimized without any lags included, despite the fact that lagged air transport industry growth is a robustly significant predictor of recommendation acceptance even in this specification (see Table 3). On the other hand, for the recommendation-level logit model (Eqn. 2), the AIC/BIC values appear decreasing in additional lags ($t-3$ and $t-4$) despite the fact that none of these coefficients appear to have a statistically significant effect on recommendation acceptance (nor large point estimates that may have been noisily estimated). Importantly, however, the inclusion of additional lags does not affect the precision nor the magnitude with which the main effect of interest (on Real Air Transport Industry Growth$_{t-1}$) is estimated. The paper thus focuses on two lags as the preferred specification.

3 Aircraft Utilization Rates and Recommendation Acceptance

Another aspect of the aircraft make involved in a given recommendation that may affect adoption incentives is its 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). Table A2 shows both the summary statistics of the fraction of recommendations accepted in each utilization quantile, and the coefficients of an extended regression adding available seat mile (ASM) quantile dummies to the full specification of Table 1 (column 3). The first four columns consider utilization rates of the aircraft make involved in the recommendation source accident, whereas the other columns focus on aircraft makes mentioned in the recommendation text.

Table A2: Aircraft Utilization and Recommendation Adoption Rates

	Source Accident Make					Recommentation Text Make			
ASM Quantile	Mean (Accept)	Std. Dev.	N	Odds Ratio		Mean (Accept)	Std. Dev.	N	Odds Ratio
1	.793	.406	169			.857	.354	49	
2	.583	.498	48	0.740		.857	.378	7	0.592
				(0.283)					(0.794)
3	.693	.462	189	0.789		.750	.442	24	0.346*
				(0.175)					(0.196)
4	.793	.406	179	1.062		.825	.385	40	1.579
				(0.325)					(1.759)
5	.765	.424	799	1.168		.842	.366	177	1.869
				(0.331)					(1.033)
Total	.756	.430	1,384			.835	.372	297	

Table displays summary statistics of indicator variable that a recommendation received an "Acceptable" FAA response (=1) across available seat mile (ASM) quantiles of source accident (or recommendation text mentioned) aircraft makes (e.g., Boeing, Cessna) in accident year (or recommendation issue year), with odds ratio estimates from Table 1 Col. 3 Logit regression extended to include ASM quantile dummies, with standard errors in parentheses. * p<0.1.

While differences in recommendation adoption rates across utilization quantiles are mostly statistically insignificant, the point estimates suggest a U-shaped pattern whereby recommendations in the second and third quartile are relatively less likely to be adopted than those for the smallest or largest aircraft manufacturers. One reason for this imprecision is the sharp decline in sample size for these regressions. On the one hand, utilization data are only available for aircraft operated by large certified U.S. air carriers subject to the relevant reporting requirements (e.g., annual operating revenues of $20 million or more). Consequently, certain types of aircraft involved in accidents and/or recommendations may not be featured in the utilization data (e.g., Cirrus Aircraft). Utilization data are also available only starting in 1991. It should further be noted that one potential bias in these data is that they under-estimate utilization for smaller aircraft commonly used in private or general aviation but logging comparatively few available seat miles for large certified air carriers. Finally, NTSB recommendation text flags for aircraft manufacturer names provide only limited proxies for recommendation target aircraft makes, as regulated parts or procedures may apply to aircraft not explicitly mentioned in the text. Measurement error thus surely adds to the noisiness of Table A2.

4 Split Sample: Democratic vs. Republican Administrations

Table A3 presents the pooled and split sample results comparing FAA behavior under Republican and Democratic administrations. Unfortunately, the small number of observations for Democratic administrations (12 years in the full data availability sample of 1978-2011 net of the effective loss in observations due to the 2 year-lags) severely limits the statistical power of this comparison. The Chow F-statistic comparing these models comes out to 1.604. Given the critical values from the corresponding $F(11, 10)$ distribution, we thus fail to reject the null hypothesis of equal coefficients at conventional levels of significance (Prob > F = 0.2319).

Table A3: Aggregate Level Results: Linear Model Split Sample

Dep. Var.: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response			
	(1)	(2)	(3)
	Pooled	Republican	Democrat
Air Transp. Industry Growth$_t$	0.002	0.002	0.002
	(0.002)	(0.002)	(0.007)
Air Transp. Industry Growth$_{t-1}$	0.006***	0.006***	0.001
	(0.002)	(0.002)	(0.005)
Air Transp. Industry Growth$_{t-2}$	-0.000	0.001	-0.002
	(0.002)	(0.002)	(0.005)
Real GDP Growth$_t$	0.002	-0.007	0.009
	(0.007)	(0.009)	(0.018)
Real GDP Growth$_{t-1}$	-0.004	-0.013	0.024
	(0.008)	(0.008)	(0.028)
Real GDP Growth$_{t-2}$	0.024***	0.017*	0.015
	(0.008)	(0.008)	(0.019)
# Recs. Issued$_t$	-0.000	-0.001	0.002
	(0.000)	(0.001)	(0.001)
Total Major Accident Fatalities$_t$	0.000*	0.000*	-0.000
	(0.000)	(0.000)	(0.000)
Total Major Accident Fatalities$_{t-1}$	0.000	0.000	
	(0.000)	(0.000)	
Year	-0.003	-0.003	-0.007
	(0.002)	(0.003)	(0.006)
Constant	5.790	7.335	14.202
	(3.687)	(5.916)	(11.846)
Observations	32	20	12
Adj. R^2	0.614	0.480	0.760
Error Sum of Squares (ESS)	0.0897	0.0230	0.0106

Table presents results for OLS regression of the fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on indicated control variables. Column 2 (3) limits sample to years with Republican (Democratic) presidents. Standard errors in parentheses. (*** p<0.01, ** p<0.05, * p<0.1).

5 Alt. Industry Measures: Operating Margins and Employment

Beyond oil prices, I also explore two other production-side measures of industry conditions: airlines' *operating margins* as defined an employed by Rose (1990) in her analysis of airline profitability and safety, and total employment in the air transport industry. It should be noted that both of these variables have conceptual shortcomings as industry surplus measures for the purposes of this study. While Rose (1990) uses operating margins (defined as operating revenues/operating costs - 1) to compare profitability across individual airlines, here we need a measure of overall aviation industry surplus. I compute aggregate operating margins as an analog measure (defined as total operating revenues /total operating costs - 1), but note that this masks heterogeneity across airlines and fails to capture air industry operators that are not major airlines subject to the relevant financial reporting requirements. Similarly, while the number of workers employed in air travel provides a measure of the industry's potential strength as a stakeholder group, declines in employment could also result from technological change that improves productivity and reduces airlines' costs, thus increasing industry surplus (e.g., modern jet aircraft no longer need a flight engineer and can reliably fly with two pilots). I obtain data on U.S. airlines' aggregate operating revenues and costs from the trade association *Airlines for America* (which, in turn, compiles these data from Bureau of Transportation Statistics Form 41 Financial Reports, 1977-2015), and air industry employment data from the Bureau of Labor Statistics (1990-2015).[1] In addition to these measurement and conceptual issues, it turns out that both of these variables' time series are dominated by unprecedented declines in the aftermath of the terrorist attacks of September 11, 2001. As criminal and terrorist activity fall outside the investigative authority and focus of the NTSB - whose investigations focus on *accidents* - the attacks did not constitute a source event for new NTSB safety recommendations.[2] While the events of 9/11 led to fundamental changes in the FAA's authority over aviation security,[3] their effect on the FAA's decision-making pertaining to NTSB safety recommendations would thus be expected to be indirect. Figure A1 displays the aggregate operating margin, FAA unacceptable response rate to NTSB recommendations, and the year-to-year change in air industry employment series over time.

[1] Changes in data collection protocols lead to imperfect comparability of employment data across time periods for longer time series. For example, FRED provides data for the total number of full-time and part-time employees in Air Transportation from 1948-1987, 1987-2000, and 1998-2016. The overlapping years between the latter two series do not, however, match. In addition, the 1987-2000 FRED series does not align with Bureau of Labor Statistics data on employment in Air Transport from 1990-2016. While some disagreement should be expected as the latter are seasonally adjusted while the former are not, the series disagree by a factor of almost two in some years. The Bureau of Transportation Statistics also provides employment data only in separate time series 'chunks.'

[2] Formally, after an event, if "circumstances reasonably indicate that the accident may have been caused by an intentional criminal act, the [NTS]Board shall relinquish investigative priority to the Federal Bureau of Investigation" (FBI and NTSB, 2005).

[3] Most aviation *security* responsibilities were transferred away from the FAA after Congress created the Transportation Security Administration in late 2001 and the Department of Homeland Security in 2002 (GAO, 2003). However, the FAA remains the responsible federal agency for regulating aviation *safety*, which is also the focus of NTSB recommendations and this study's analysis.

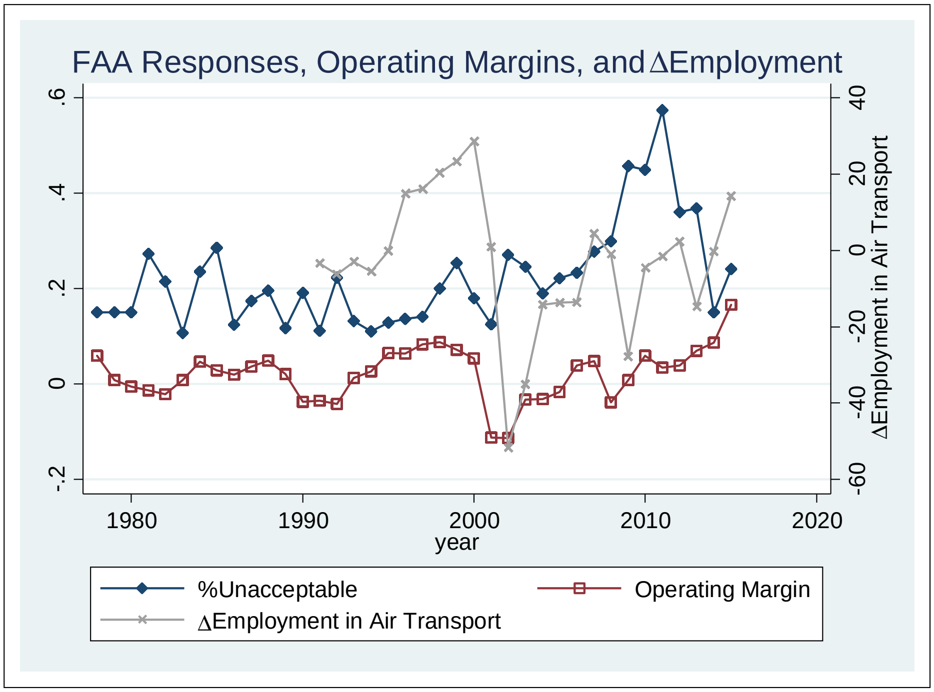

Figure A1

Both airline operating margins and air industry employment saw their largest declines in 2001-2002 compared to the rest of the data series. While there was simultaneous uptick in the FAA's rejection rate of NTSB safety recommendations - in line with pro-cyclicality of regulatory stringency - this change was modest in magnitude.

Table A4 : Robustness: Employment and Operating Margins (Linear Aggregate Model)

Dep. Var.: Share of NTSB Recs. Issued at t with "Acceptable" FAA Response				
	(1)	(2)	(3)	(4)
	%Accpt.	%Accpt.	%Accpt.	%Accpt.
Air Transport Employees$_t$	0.001	0.001		
	(0.001)	(0.001)		
Air Transport Employees$_{t-1}$	-0.002	-0.002		
	(0.002)	(0.002)		
Air Transport Employees$_{t-2}$	-0.001	-0.001		
	(0.001)	(0.000)		
Operating Margin$_t$			-0.057	-0.057
			(0.494)	(0.421)
Operating Margin$_{t-1}$			-0.322	-0.322
			(0.517)	(0.568)
Operating Margin$_{t-2}$			-0.286	-0.286
			(0.432)	(0.351)
Real GDP Growth$_t$	-0.004	-0.004	0.010	0.010*
	(0.012)	(0.007)	(0.008)	(0.005)
Real GDP Growth$_{t-1}$	0.007	0.007	0.004	0.004
	(0.018)	(0.018)	(0.008)	(0.011)
Real GDP Growth$_{t-2}$	0.023*	0.023	0.019**	0.019**
	(0.010)	(0.017)	(0.008)	(0.009)
Observations	38	38	20	20
Std. Error Adjustment	-	Newey-West	-	Newey-West
Adj. R-squared	0.442		0.834	

Table presents OLS regression of the fraction of NTSB recs. issued in year t receiving "Acceptable" or better FAA response on indicated control variables plus controls for # recs. issued in year t, major U.S. air crash fatalities at t and $t-1$, an indicator for Republican presidency at t, a linear time trend, and a constant. (*** p<0.01, ** p<0.05, * p<0.1).

6 NTSB Recommendation Volumes

Table A5 presents results for regressions of the number of NTSB recommendations issued each year on the explanatory variables of the benchmark specification. Neither contemporaneous nor lagged industry or GDP growth appears to be significantly associated with NTSB recommendation issuance.

Table A5: Volume of NTSB Recommendations Issued by Year

Dependent Variable: Number of NTSB Recommendations Issued in Year t					
	(1)	(2)	(3)	(4)	(5)
Air Transp. Industry Growth$_t$	-0.040	0.220	-0.040	0.220	0.278
	(0.864)	(0.716)	(0.964)	(0.706)	(0.747)
Air Transp. Industry Growth$_{t-1}$	-0.426	-0.125	-0.426	-0.125	-0.296
	(0.833)	(0.693)	(0.789)	(0.919)	(0.840)
Air Transp. Industry Growth$_{t-2}$	0.312	0.357	0.312	0.357	0.434
	(0.780)	(0.657)	(0.775)	(0.518)	(0.701)
Real GDP Growth$_t$	-0.573	-1.205	-0.573	-1.205	-1.287
	(3.493)	(2.910)	(2.425)	(2.864)	(2.979)
Real GDP Growth$_{t-1}$	-0.463	-2.287	-0.463	-2.287	-1.979
	(3.722)	(3.224)	(4.277)	(4.260)	(3.392)
Real GDP Growth$_{t-2}$	-2.601	0.085	-2.601	0.085	-0.536
	(3.383)	(3.236)	(1.547)	(2.247)	(3.692)
Total Major Accident Fatalities$_t$		0.019		0.019	0.020
		(0.043)		(0.024)	(0.044)
Total Major Accident Fatalities$_{t-1}$		-0.062		-0.062*	-0.044
		(0.042)		(0.034)	(0.063)
Republican President$_t$		-37.016***		-37.016***	-35.019***
		(10.451)		(11.716)	(11.912)
Year	-2.189***	-2.799***	-2.189***	-2.799***	-2.649***
	(0.691)	(0.662)	(0.728)	(0.414)	(0.785)
Observations	32	32	32	32	31
Adj. R^2	0.132	0.419			0.354
Durbin-Watson Statistic	1.425	2.272			
Standard Error Adjustments:			Newey-West	Newey-West	

Table presents results for OLS regression of the number of recs. issued in year t on the indicated control variables plus a constant. Columns (3)-(4) use Newey-West standard errors. Column (5) excludes the year 2002 to demonstrate that the marginally significant negative coefficient on lagged air crash fatalities in Column (4) is driven by the terrorist attacks of 9/11, which caused many fatalities but fall outside the NTSB lead investigative authority and did not lead to NTSB recommendations.