Crash and Learn: Consumption Externalities and the Reduction of Aircraft Accidents

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Abstract:
We learn about a product's safety profile through the experience of others. Because adverse effects are more likely to be discovered the greater the users of a product, consumption of potentially dangerous products generates a positive externality. The obvious problem in estimating consumption externalities in safety is that if there are consumption externalities greater consumption makes products safer. But consumers prefer safer products so safer products are likely to be consumed by more people. So is greater consumption a cause of safety, an effect of safety, or both a cause and effect? We take advantage of a quasi-experiment to estimate the effect of consumption externalities on safety by estimating the impact of a change in consumer preferences for safety generated by a ban on the right to sue the product's manufacturer. In 1994 congress passed the General Aviation Revitalization Act (GARA). GARA cut off the right to sue the manufacturer of any plane 18 years or older. The law effectively moved any general aviation aircraft over 18 years of age from a regime of strict liability to one of no liability. A well known result from models of liability is that a move from strict liability to no liability increases consumer investments in safety. We find that the probability of an aircraft accident falls the more aircraft in the same consumption group that are not covered by liability.

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The authors wish to thank Jens Hennig of the General Aviation Manufacturer's Association for providing us with production data, George Priest for providing the data on liability payouts and Aviation Data Services for their assistance with the registry data.

1. Introduction

We learn about a product's safety profile through experience. Fortunately, Joe's experience can result in Cathy's learning. Information about a product's safety profile is a public good so the more people who experience the same good the more society learns. Pharmaceuticals are an important example: adverse effects are more likely to be discovered the greater the number of patients prescribed the drug.[1] In effect, there are network externalities in safety from the information provided by the consumption of others. All patients are guinea pigs but it's safer to consume a drug previously consumed by many other guinea pigs. In this paper, we examine how consumption externalities influence the safety of another good, general aviation aircraft.

General aviation aircraft are all non-military aircraft that do not carry regularly scheduled commercial passengers. Although dominated by small, single-engine planes, general aviation also includes multi-engine turboprops, jets and helicopters. The majority of these aircraft are used recreationally but sizable percentages are used by government and business for everything from emergency rescue to deep forest logging.

The obvious problem in estimating consumption externalities in safety is that if there are consumption externalities greater consumption makes products safer. But consumers prefer safer products so safer products are likely to be consumed by more people. So is greater consumption a cause of safety, an effect of safety, or both a cause and effect? Any attempt to estimate safety externalities must break the circle of endogenity.

In this paper we take advantage of a quasi-experiment to estimate the effect of consumption externalities on safety. We focus on an induced change in consumer preferences for safety

[1] A large clinical trial might involve 5000 patients so even a large trial will not discover a rare but serious side-effect that could kill thousands. For example, the FDA approved fenfluramine in 1973 but it wasn't prescribed much until combined in the late 1990s with phentermine. Use of the combination as a diet aid ("fen-phen") exploded until serious heart-valve defects were found in women using the drug. The defects, however, were caused by fenfluramine and not phentermine or the combination. Society learned of the problems with fenfluramine only because of increased use.

generated by a ban on the right to sue the product's manufacturer. In 1994 congress passed the General Aviation Revitalization Act (GARA) the centerpiece of which was a "statute of repose" that cut off the right to sue the manufacturer of any plane 18 years or older. The law effectively moved any general aviation aircraft over 18 years of age from a regime of strict liability to one of no liability. A well known result from models of liability is that a move from strict liability to no liability will increase consumer investment in safety and reduce manufacture's investment (Shavell 1987, Landes and Posner 1987).

The quasi-experiment created by GARA allows use to estimate the impact of increased consumer investment in safety holding constant a number of features of the aircraft. Since the change from strict liability to no liability is triggered by the aircraft turning 18 we have observations on the same manufacturer and model of aircraft with and without liability. In addition, after 1994 each year has new aircraft transitioning into no liability status and causing owners to increase their investments in safety.

We estimate what happens to the probability of an accident as the number of aircraft not covered by liability increases. In a random sample of 20,000 aircraft from 1982-2003 we find that as more aircraft move off liability the probability of an accident decreases. This finding is consistent with a preference externality in which others' investment in safety causes an increase in total-safety proportionate to the size of the product line.

There are 210 thousand general aviation aircraft in the United States and in an average year about 2250 are involved in accidents every year, 430 of them resulting in at least one death. The accident rate in general aviation is about 24 times higher than for scheduled commercial aircraft. Senator Paul Wellstone, John Walton (son of Wal-Mart founder Sam Walton), John F. Kennedy Jr., John Denver, and Payne Stewart are just a few well known people to have died in general aviation aircraft in recent years. As the list indicates, general aviation accidents are one of the few areas in which the rich have a higher death rate than the poor. Beyond the general interest in aviation safety the results in our paper have important implications for models comparing the relative efficiency of strict liability, various negligence standards and no liability for dangerous products. We know of only one paper, Dharmapala et al (2005), which examines the efficiency of strict liability when individuals' investment in safety reduces the cost of safety for other parties.

2. The Framework

Theoretical treatments of preference externalities have identified several avenues by which an individual's product choice can impact others. In one of the earliest treatments Spence (1976) models the interaction of fixed costs and a mix of consumer types. Consumer's with more common types are more likely to be able to consume a product close to their ideal.[2] Consumption externalities of this kind have been studied in areas as diverse as newspaper circulation, local radio markets and pharmaceuticals (see Berry and Waldfogel, 2003, George and Waldfogel, 2003 Linchberg and Waldfogel, 2003 and Waldfogel, 2003). It is certainly possible to have preference externalities in safety of the kind considered by Spence. If safety has a high fixed cost, say because of research and development, then each individual that purchased the product lowers the cost of safety since the cost is divided over more consumers. The preference externality we estimate in this study is slightly different from the high fixed cost variety estimated in previous studies and is similar to network effects (see Katz and Shapiro (1994)). Since our quasi-experiment takes place long after the aircraft has been built the variance created by GARA does not provide any information on the impact of fixed costs. The variance created by GARA does allow us to estimate the impact of current owners' investment in safety on the safety of others.

[2] See also Bresnahan and Reiss (1991) and Dixit and Stiglitz (1977)

2.1 General Aviation Revitalization Act of 1994

Although general aviation has existed since the Wright Brothers it reached its zenith in the 20 years following World War II as thousands of ex-airmen returned to civilian life creating a pool of recreational pilots. By the late 1970s a diverse product line manufactured by over 29 companies produced over 17 thousand planes a year (GAO 2001). The industry went into a tailspin in the late 1970s and early 1980s when aircraft shipments fell from almost 18,000 in 1978 to under 2000 by 1984 and half that again by 1994 (GAO 2001). The industry declined for a number of reasons including saturation and downturn in the economy in the early 1980s but a major factor was the rising cost of product liability.

Figure 1 (based on Priest 1991) presents data from the General Aviation Manufacturers Association on the explosive growth of liability payouts in the late 1970s and early 1980s. By 1985 liability insurance and litigation cost were the single largest expense in airplane manufacture accounting for between 50 to 70 thousand dollars per aircraft, about half of the total purchase price (Priest 1991, GAO 2001, Schwartz and Lorber 2002).

A Figure 1 suggests, liability payments did not appear to be either a response to higher accident rates nor a cause of lower accident rates. Further evidence comes from a study of 203 crashes involving Beech aircraft between 1983 and 1986. All of the crashes were studied by the Federal Aviation Administration (FAA) or the National Transportation Safety Board (NTSB) and *none* of the accidents were found to be due to manufacturer defects. Nevertheless there was a lawsuit for *every* accident that occurred and an average claim of 10 million dollars. Defending these lawsuits cost Beech more than a hundred million dollars in legal fees (Schwartz and Lober 2002, Martin 2001). Cessna's legal fees were similar, 20-25 million dollars a year or about the same amount as they spent on research and development. Liability insurance dried up around this time with one Lloyd's underwriter saying "We are quite prepared to insure the risks of aviation, but not the risks of the American legal system."[3,4]

2.2 The Long Tail Wags the Dog

In 1986 Cessna Aircraft Company stopped producing general aviation aircraft and Beech Aircraft shut down almost all of its general aviation lines. In 1991 Piper Aircraft, whose sales in 1990 had dropped to 2% of 1970 levels, declared bankruptcy.

Liability was especially devastating to the aircraft industry because airplanes are a durable good. The major manufacturers, Cessna, Beech and Piper, have been producing planes since 1927, 1932 and 1927 respectively and prior to GARA they could be sued for any aircraft that they had ever produced. In our data, for example, we have information on planes that were built in 1911 and are still flying today. A plane built in 1911 is more likely to be a museum piece occasionally flown for show than a working aircraft, nevertheless the average age of the general aviation fleet is over 30 years and thousands of aircraft built in the 1930s and 1940s are actively flown today. Thus it was neither infeasible nor uncommon for a manufacturer to be sued for a production defect on an aircraft produced decades earlier.

In response to the industry's decline, Congress passed the General Aviation Revitalization Act in 1994 (GARA). The 18-year statute of repose created by GARA is quite broad. The limitation is defined as "18 years with respect to general aviation aircraft and the components,

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[3] Cited in Martin (2001, 483-484).

[4] Overall Craig (1991) finds that about one third of all accidents end up in litigation with variation depending on the manufacturer involved. He also cites evidence that in 1985 the total cost of product liability was on the order of $210 million dollars. We can use this number to get a back of the envelope calculation of the value of liability to aircraft owners. If we assume that the administrative costs of small aircraft liability are the same as the tort system overall, about 54 percent of benefits, then accident victims received $96 million dollars. If we again assume that these lawsuits in 1985 covered accidents in the past 5 years, we can construct an approximate expected value for each accident or aircraft. There were approximately 3000 accidents per year during this time period and approximately 210,000 general aviation aircraft (GAMA). Thus our back of the envelope calculation is that in 1985 liability was worth approximately $32,200 to an accident victim and $460 to the average general aviation aircraft owner. Interestingly, the consumers of airplanes in the form of the Aircraft Owners and Pilots Association were key players in the fight to *reduce* manufacturer liability.

systems, subassemblies, and other parts of such aircraft." (Rodriguez 2005). It runs from the date the aircraft was delivered to the first purchaser or for components when the component was installed. In effect, GARA chopped the long tail of liability 18 years after the date of manufacture.[5] Thus, in one fell swoop in 1994 airplane manufacturers were relieved of an enormous liability overhang and as planes age they continually move from a regime of strict liability to one of no liability.[6]

Most observers suggest that GARA was very effective. In 1997 Cessna's general counsel estimated that annual number of new lawsuits was less than half that of the 5 years prior to GARA (Rodriguez, p 601 2005). The GAO reported that typical manufacturers saw an even bigger drop from a high of 900 lawsuits a year in the early 1980s to 80 a year in 2001.

Most importantly, Cessna and Beech began producing general aviation aircraft again soon after GARA was passed. Piper, reorganized after bankruptcy as New Piper, also reentered the market in 1995. The CEO of New Piper made it plain that without GARA they would not have reentered the market saying "We are The New Piper because of GARA and its limiting effect on the enormous liability tail."[7] Figure 2 shows that industry-wide production increased substantially after GARA was passed.[8]

Knowing that they could be sued, manufacturers prior to GARA had an incentive to try to keep owners informed of safety issues. Manufacturers, however, primarily control and have data on manufacturing, not the safety characteristics and issues involved with decades old aircraft. In

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[5] We do not know the exact date of delivery to the first purchaser so we mark the end of liability as 18 years from the date of manufacture. The first purchaser includes dealers and lessors as well as primary consumers so planes are almost always delivered to the first purchaser soon after manufacture (Schwartz and Lorber 2002).

[6] GARA also had the effect of banning recovery of damages from most other sources. A distributor or lessor, for example, can typically assert all defenses available to the manufacturer. Given this bar it is unlikely that injured consumers were able to recover their damages from other sources once GARA's ban was in place.

[7] General Aviation Manufacturers Association, Report to the President and Congress: The Results of the General Aviation Revitilization Act (1996).

[8] Figure 2 is based on data for of the types of aircraft covered by GARA and which we use in our estimates. As such it differs slightly from GAMA data on shipments as that data includes some aircraft over 20 seats. Nevertheless the GAMA data and our sample show the same pattern but somewhat higher production levels in the GAMA data.

contrast, consumers as a group have much better information about these issues than manufacturers. Although a potential liability burden to manufacturers the long tail is a boon to owners. The long tail is a sample upon which knowledge is developed and disseminated and the longer the sample the more the knowledge. Owners of older aircraft, for example, often band together in "type clubs" to swap information on proper airplane maintenance, handling and updates. We describe in greater detail further below how this and other features of aircraft regulation created a safety network. Key to our argument is that after GARA aircraft manufacturers had an incentive to reduce investments in generating new safety information on older aircraft but owners had a greater incentive to engage in consumer protection measures which increased the safety of all through the network effect.

2.3 Role of Regulation in Creating a Safety Network

Aircraft are one of the most regulated products in the United States and a critical feature of the regulatory process is the creation of a *safety network*. The basic pattern of the safety network is problem discovery at the airplane level followed by collection, analysis and dissemination of safety information by the FAA and also by private clubs. Every airplane accident, for example, is investigated by FAA or NTSB or both. If problems are detected with the aircraft, safety information can be issued to every owner through Airworthiness Directives (discussed below). Most problems, however, are not discovered through accident reports.

Most of the safety information for general aviation aircraft comes from required inspections by private mechanics who report problems to the FAA. If the FAA notices a pattern of problems they will issue an Airworthiness Directive. Airworthiness Directives typically require a specific action, although some are merely advisory. Mandates can range from a requirement to fix a particular component, conduct regular inspections for cracks or corrosion or simply require that pilots not perform certain maneuvers. Gilligan (2004) argues that Airworthiness Directives are a good indication of aircraft quality in that they provide an aircraft owner with a comprehensive list of safety problems experienced by others owners of the same aircraft. Airworthiness Directives are typically issued for a given model of aircraft, a fact which motivates our choice of manufacturer and model as the locus for the consumption externality.

One of the sources of information that the FAA uses to issue Airworthiness Directives is the FAA Service Difficulty Report System (SDR) which maintains extensive safety information both from commercial airlines and general aviation.[9] The SDR system is similar to the FDA's MedWatch Adverse Event Reporting program which collects information from physicians and consumers about adverse events. As with MedWatch, compliance with the SDR system is difficult to determine since the FAA requires that “serious” service difficulties be reported but it does not monitor or enforce compliance. The SDR system has been criticized for incomplete reporting but the GAO has concluded that it is useful for understanding difficulties with particular types of aircraft (GAO 1991). Most importantly, “Submitting an SDR can help alert other owners, mechanics or inspectors of problems that may arise in aircraft no longer supported by an active manufacturer (FAA 2003).”

Most accidents are caused by pilot error (GAO 2001). The FAA’s pilot certification and continuing education programs also facilitate a safety network. For example, pilot continuing education classes teach pilots flight safety, often in the context of issues related to specific aircraft. Similarly, pilots involved in accidents or near-accidents are sometimes required to explain their mistake to their peers – much as physicians must forthrightly discuss their errors in Morbidity and Mortality (M&M) conferences.

[9] The FAA requests that “In order to make the database as useful as possible, owners or mechanics are encouraged to submit SDRs with complete confidence that they will not lead to enforcement actions.”

In addition, the Back to Basics (Business Aviation Seminars for Information, Concepts and Solutions) program has written materials on takeoffs, landings and flight maneuvers. The FAA conducts safety seminars administered by district offices and the Airline Owners and Pilot's Association has a Flight Safety Foundation that conducts seminars.

Perhaps the most important source of information for general aviation pilots are "type clubs." According to the FAA

> The owners of older airplanes routinely form organizations, especially when the manufacturer no longer exists *or provides little consumer support*. The organizations (referred to as "type clubs") share information and are often considered the best source of continued airworthiness concerns that could be or develop into safety problems.[10]

The clubs are the primary source of expertise regarding the maintenance of a particular model and will provide members with information on service difficulties. These clubs also typically provide information on flight safety that goes beyond mechanical difficulties instructing members on how to safely maneuver their aircraft, potential avionics upgrades and inspection techniques. Another source notes the following:

> A possible list of services offered might include: a magazine to pass type-related information, news and events, a website, technical question support from aircraft type experts, buyers guides, conventions and fly-ins, information on Airworthiness Directives that apply, information on Supplemental Type Certificates available, type-specific classified ads (often on-line), background and aircraft type historical information, maintenance tips publications, operating tips information, maintenance and aircraft systems courses, aircraft type conversion training programs, type specific insurance, formation flying training and scholarships amongst other possible services.

Most importantly type clubs for types of aircraft that have greater production runs tend to be larger and offer more services.[11]

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[10] Emphasis added – we expect less manufacture support after GARA for older aircraft.
[11] Wikipedia "Aircraft Type club" last accessed August 27, 2006, http://en.wikipedia.org/wiki/Aircraft_type_club.

One key feature of all of these safety programs is that beyond some FAA required inspections (which are not generally considered onerous) use of these programs is at the discretion of the owner. Owners can increase the frequency and quality of inspections, they can monitor or not monitor Airworthiness Directives and SDR reports and choose how strictly to follow the instructions therein, they can attend seminars on safety or not and they can choose to join or not join type clubs. The incentives to follow through on these investments increase when manufacturers are no longer potentially liable for accidents.

3. Data

Our primary data source is the annual Aircraft Registration Master File which contains detailed records on all U.S. Civil Aircraft registered with the FAA. It includes commercial air carrier and general aviation aircraft. The registry is essentially the universe of aircraft operated in the United States but does not contain information on aircraft in foreign countries. As such our estimates of preference externalities may be understated if foreign aircraft also provide a consumption externality.

The FAA updates but does not store the registry but we were able to obtain copies of the registry from a private source for 1987, 1991 and 1994-2003.[12] The registry contains information on when the aircraft first entered the registry and because aircraft almost never exit the registry without an accident we are able to construct a panel back to 1982 using the data. For aircraft that were involved in accidents prior to 1987 we were able fill in the panel using the accident data discussed below.

[12] Previous years of the data do not seem to be available from any of the private companies supplying the information. Only Aviation Data Services had data back to the 1980s.

The registry contains information on the year the aircraft was manufactured, the aircraft's approved uses a code for the manufacturer and model of the aircraft as well as an aircraft id. The registry allows us to construct an index of the number of other owners of a registered aircraft of a specific manufacturer and model. We refer to the manufacturer-model cohort as the consumption group. The size of the consumption group ranges from 1, for aircraft with a unique design or for very old aircraft to about 27,000 for the Cessna 172 Skyhawk.[13]

The data on accidents come from the FAA and NTSB accident data 1982-2003. The data are linked to the Registry data via the aircraft identifier. Because the FAA recycles aircraft identifiers the data is also merged on serial number.

While the Registry's comprehensiveness is beneficial for constructing the population of general aviation aircraft its drawback is that it contains aircraft that are not actively flown and contains no information on the amount of use of aircraft in the database. To measure use we merge the Registry data to the General Aviation and Air Taxi Activity Survey (GAATA) from the FAA. The GAATA survey contains data on the number of hours flown and percent of aircraft regularly flown for manufacturer and model although this is not broken down by aircraft age. Also after 1996 the FAA published this data only in six broad categories rather than by manufacturer and model as it had done previously. To construct a continuous series of hours flown for the years after 1996 we estimate the manufacturer model specific trend using the log of the manufacturer model hours as a dependent variable and constructing a set of interactions with log broader index.

[13] One way to verify the accuracy of the Registry is to compare it to the GAMA production data which comes from the manufacturers directly. When find a correlation between the number produced and the number in the registry of 61%. When we restrict the correlation to those aircraft manufactured after 1982 the correlation rises to 87% suggesting that much of the discrepancy is normal attrition. Craig (1991) claims that 20-30% of the aircraft produced in the US prior to 1981 were exported. In 1981 the US became a net importer of aircraft. Since exported aircraft would not be the US registry this also explains the difference.

$$\log(hours\ \ flown_{it}) = \sum_{i}^{n} manufacturer\ model_i + \sum_{i}^{n}\sum_{t}^{T} manufacturer\ model_i * year_t$$
$$+\sum_{i}^{n} manufacturer\ model_i * \log(average\ hours\ \ flown_{kt})$$
$$+\sum_{i}^{n}\sum_{t}^{T} manufacturer\ model_i * \log(average\ hours\ \ flown_{kt}) * year_t$$

where *year* is an indicator variable for the year of the observation *t=1 to T*, *manufacturer model* is an indicator variable for the type of aircraft *i=1 to n* and hours flown is the GAATA estimate of average hours flown for the particular manufacturer-model of aircraft, *n*, and *average hours* is the estimate of average hours flown from the broader index. Every manufacturer-model combination, *n*, is contained in only one of the broader indices, *k*. We perform a similar estimate for percent active.

For our robustness checks we construct several additional measures. The first is data on manufacturers who are still actively producing aircraft. We use the production data from the General Aviation Manufactures Association to determine if a manufacturer is still producing aircraft. We also utilize data on the number of Airworthiness Directives and SDR from the FAA and data on the price of the manufacturer model by the year the aircraft was built. The price data comes from the *Aircraft Bluebook: Historical Value Reference.*

To construction the sample we examine only those aircraft covered by GARA. In addition we limit the analysis to aircraft built after 1936 since the manufacturer model codes do not accurately differentiate many of the aircraft manufactured before that date.

Our final restriction is to estimate the model using only fixed wing aircraft. Fixed wing aircraft are far more common than helicopters which involve substantially different safety issues (GAO 2001). In addition we do not have controls for hours used and percent active for a significant number of helicopters and our price data does not include helicopters.

The means and standard deviations of the data are included in Table 1.

4. Results

4.1 Accident Results

Our data encompasses the universe of general aviation aircraft between 1982 and 2003. This gives us over 210,000 aircraft and over 4 million aircraft years. Given the difficulty in analyzing such a large panel we draw a random sample of 20,000 aircraft giving us 366,446 aircraft years.

A second issue is that aircraft accidents are rare events. Since we are interested in the impact of product line size on safety we would like to oversample accidents. To correct for the bias due to oversampling we use Manski and McFadden's (1981) method of choice based sampling. We divide our sample into aircraft that are not involved in an accident between 1982 and 2003 and aircraft that had at least one accident during the period. We then draw 10,000 aircraft from each subset making the sample proportion 50% for each group. Since we have the population of aircraft we know the true proportion of the sample is 13% for accidents and 87% for non-accident aircraft thus we can construct a weight that scales down accident aircraft and scales up non-accident aircraft.

$$\text{Weight}=(.13/.5)*\text{accident sample}+(.87/.5)*(\text{non-accident sample})$$

Since we are interested in the probability of an accident in each year we estimate a discrete time survival model (see Jenkins 2005). The model allows us to easily deal with three features of the data. First, although our sample period begins in 1982 many of the aircraft have been flying for considerably longer and hence, in the terminology of survival models, have been in the risk set for a considerable time period before 1982. Similarly the model allows us to easily model new entrants to the sample. Second an accident usually does not result in the destruction of the aircraft. Thus an aircraft is likely to remain in the risk set even after an accident. Finally the model allows us to deal with the truncation created by the fact that we do not observe accidents after 2003.

Specifically the model we estimate is the complementary log-log model

$$\Pr(accident \mid x_j) = 1 - \exp\left\{-\exp(x_j \beta_j)\right\}.$$

Where x_j are the independent variables discussed below. The model is estimated with robust standard errors clustered on the individual aircraft. We model the hazard rate as the log of the aircraft's age. The model with year manufactured fixed effects is given by

$$\Pr(accident_{it}) = \beta_1 N_i * P_{it} + \beta_2 N_i + \alpha_1 x_{it} + \delta_1 \log(age_i) + \sum_{t=1}^{22} \phi_t year_t + \sum_{j=1}^{68} \varphi_j mfg\_year_i + \varepsilon_{\text{it}} \quad (1)$$

We also estimate the model with both year manufactured and consumption group (manufacturer-model) fixed effects. For the model with consumption group fixed effects we eliminate the number of aircraft due to colinearity. Thus the model estimated with a full set of fixed effects is

$$\begin{aligned}\Pr(accident_{it}) = \beta_1 N_i * P_{it} + \alpha_1 x_{it} + \delta_1 \log(age_i) + \sum_{t=1}^{22} \phi_t year_t + \sum_{j=1}^{68} \varphi_j mfg\_year_i \\ + \sum_{k=1}^{501} \gamma_k mfg\_model_i + \varepsilon_{\text{it}} \end{aligned} \quad (2)$$

where $accident_{it}$ equals 1 if the aircraft *i* has at least one accident during the year *t*, N_i is the number of aircraft in the cohort, P_{it} is the percentage of the cohort which is no longer able to sue the manufacturer for damages in the event of an accident (i.e. zero prior to GARA and the percentage of aircraft over 18 in the cohort thereafter), log(age_i) is the log of aircraft age, $year_t$ is an indicator variable equal to one for the respective year *t*, mfg_year_i is an indicator variable equal to one for the year in which the aircraft was manufactured, and mfg_model_i is an indicator variable for the consumption group, and x_{it} are the control variables.

The controls include the estimate of log of hours flown and percentage active, the approved uses of the aircraft including approved for commuting, utility, agriculture, surveying, advertising, weather monitoring, research and development and exhibition. We also include information on whether the aircraft was owned by a business, a partnership or government. The omitted default category is individual ownership. Finally we include a control for aircraft operated commercially. Given the sample restrictions this does not include aircraft that provide regular commercial transport of passengers but does include charter flights and aircraft rented for sight seeing.

The results are presented in Table 2. Column 1 presents the results for equation (1). The coefficient on the number of aircraft without liability is negative and significant. The coefficient, -.006 indicates that a one standard deviation change, 6,200 aircraft, in the size of the relevant consumption group would decrease the accident hazard rate by 3.9%: about a .43% reduction in the likelihood of an accident in a given year. In column 2 we present the results from equation 2. The coefficient is -.005 implying a .32% reduction in the probability of an accident: about a .35% reduction in the overall accident rate.

The control variables are also significant and of the expected sign. In the manufacturer model fixed effects specification the number of hours flow is positive and significant indicating that aircraft that are flown more often or farther during the year have more accidents. The percentage of aircraft that are still actively used is also significant in both specifications but switches signs depending on whether manufacturer-model fixed effects are included. Finally the log of aircraft age is positive and significant suggesting that older aircraft are more likely to be involved in an accident.

Column (3) to (4) adds two additional control variables to the regressions. The consumption externality is *magnified* by the number of users but is driven by an increase in safety investment by individuals with aircraft that are no longer covered by manufacturer liability. The individual investment effect alone could reduce accidents (although it need not do so since manufacturer's reduce investment) so we need to distinguish the individual investment effect from the effect due to the consumption externality. We have data on aircraft in the same consumption group that are under 18 (and thus covered by liability) and over 18 (and thus uncovered) so we have enough information to identify both the individual and consumption group effects. Column(3) and (4) contain estimates from the model including a dummy variable equal to one if the specific aircraft is over 18 and an interaction between over 18 and an indicator equal to one if the observation is post GARA.

In column (3) the estimate on the number of aircraft without liability is negative and significant while the individual effect is positive but not significant. The impact of the consumption group size without liability is the same magnitude as the earlier estimates suggesting that the result is not simply driven by the individual aircraft owners' increased investment in safety. The joint significance of the number of the consumption group without liability, the consumption group size, the individual aircraft being over 18, and the individual aircraft being over 18 post GARA are highly significant. Although not significant the impact of the individual aircraft losing liability coverage is positive and implies a .7% increase in the likelihood of an accident. Column (4) estimates the model both with individual aircraft's liability status and manufacturer-model fix effects. The results are similar.

4.2 Consumption Group Trends

There is safety in numbers. What is likely to matter, however, is not just today's numbers but something like "owner-years," thus older aircraft are implicitly part of a larger consumption group. Our exogenous variation lets us test this effect indirectly. The value of increased investments in safety by others in your consumption group should be lower if the consumption group has been around longer. Much as with pharmaceuticals, there is simply less to discover about older aircraft and thus the benefits of a currently large consumption group will decline with age.

We estimate equation (1) and (2) but include the number of years since the model of aircraft was first built, an interaction between this variable and the number of aircraft and a third interaction with the size of the consumption group without liability interacted with the years since the model was introduced.

$$\Pr(accident_{it}) = \beta_1 N_i * P_{it} + \beta_2 N_i + \beta_3 N_i * P_{it} * M_{it} + \beta_4 N_i * M_{it} + \beta_5 M_{it}$$
$$+\alpha_1 x_{it} + \delta_1 \log(age_i) + \sum_{t=1}^{22} \phi_t year_t + \sum_{j=1}^{68} \varphi_j mfg\_year_i + \varepsilon_{\mathrm{it}} \quad (3)$$

where M_{it} is the number of years since the model of aircraft was first introduced.

The results are contained in column (5) and (6). Because N_i, P_{it}, and M_{it} are correlated we test the joint significance of β_1 through β_5. In column (5) the coefficient on the consumption group without liability is negative but no longer significant and of smaller magnitude. The joint effect of all of the variables is, however, highly significant. An increase in the number of years since the aircraft's model was first constructed is negative and significant as is the interaction between the size of the consumption group and the years since first constructed. Consistent with the theory the coefficient on size of the consumption group without liability and the years since the model was first built is positive and significant. This implies that although larger investments in safety by individual owners improves the safety of others in the consumption group that effect is attenuated in older models. When we turn to the within consumption group results in column (6) the results are similar. The coefficients are still jointly significant but the impact of the number of the consumption group without liability is negative and significant and the interaction with the number of years since the model was first built is positive and significant.

4.2 Active Manufacturers Results

The theory of consumption externalities can be tested in another way, albeit without quite the natural experiment flavor provided by the passing of GARA. Prior to GARA a number of aircraft manufacturers had gone out of business (and had not been acquired by another company, which would have assumed their liability). In effect bankruptcy meant that these companies were judgment proof and could not be sued, the exact same experiment as provided by GARA. [14] We thus construct an indicator variable, *Active*, equal to one if the manufacturer of an aircraft or the company that acquired it are still producing aircraft. We utilize the production data from GAMA since production of aircraft not used in recreational general aviation are still producing for the purposes of this measure. Thus we estimate

$$\begin{aligned}&\Pr(accident_{it}) = \beta_1 N_i * (1 - A_{it}) + \beta_2 N_i + \beta_3 A_{it} + \\ &+\alpha_1 x_{it} + \delta_1 \log(age_i) + \sum_{t=1}^{22} \phi_t year_t + \sum_{j=1}^{68} \varphi_j mfg\_year_i + \varepsilon_{\text{it}}\end{aligned} \qquad (4)$$

where A_{it} equals one if the aircraft's manufacturer is still producing aircraft in year *t*. The results are presented in column (7) and (8). The coefficient on active manufacturer is negative and significant. This implies that the exit of a manufacturer from the market increases the accident rate. The impact is quite large. An non-active manufacturer's hazard rate is 54% higher than that of an active manufacturer. Thus a manufacturer's exit from the industry is associated with a 4% point increase in the likelihood of an accident. This is consistent with the bilateral precaution model if manufacturers have an ongoing investment in safety. The exit of a manufacturer, however, has an offsetting benefit. The coefficient on the size of the consumption group without an active

[14] See Shavell (1986) for a model of liability showing that bankruptcy will increase the safety investment of potential victims.

manufacturer is negative and significant. Thus while the exit of a manufacturer reduces safety this effect is attenuated in larger consumption groups as individuals benefit from other members of the groups' increased investment in safety.

In column (9) we include both the active manufacturer effect and the GARA effect by combining equations (1) and (4) and in column (10) we also include manufacturer model fixed effects. The results indicate both an active manufacturer effect and impact from the size of the consumption group with liability.

4.2 Other Evidence: Airworthiness Directives, SDRs and Price

In this section we examine several means through which the consumption externality is generated, increased Airworthiness Directives and SDRs. We also find further evidence for the increase in safety by examining prices in the market for used aircarft. We first estimate the impact of moving from strict liability to no liability on the number of airworthiness directives using a sample of 1167 distinct manufacturer-model aircrafts. The count is estimated by a negative binomial regression. Given the number of zeros in the data we are concerned with overdispersion. The unit of observation is again the manufacturer-model and year manufactured. Thus a Cessna 182 Skylane built in 1956 is a different observation from the same manufacturer model built in 1986 (the first and last year that particular model was built). The model for Airworthiness Directives, AD, is estimated as

$$AD_{it} = \beta_1 N_i * P_{it} + \beta_2 Accident_{it} + \alpha_1 x_{it} + \gamma_t + \delta_i + \varepsilon_{\mathrm{it}} \quad (5)$$

where N_i and P_{it} retain their meaning from above, x_{it} includes the estimates of hours flown and percentage in regular use as well as the number of accidents, $accident_{it}$, in the previous year for the manufacturer-model combination. The motivation for including the number of accident arises from the method by which in part ADs are generated. In effect a crash generates a positive externality for other consumers because the FAA or the NTSB investigates each accident. We also estimate the model using a manufacturer model fixed effect δ_i and year effects γ_t. The means and standard deviations of the data are given in Table 3

The results of this regression are shown in column 1 of Table 4. The coefficient on the consumption group interacted with the percent liable is positive and significant indicating that an increase in the number of aircraft owners who may not sue for damages following an accident increases the number of airworthiness directives. A one standard deviation increase in the number of aircraft not covered by liability increase the number of Airworthiness Directives by 2.4.

There are two possible interpretations of this. One alternative is that as aircraft owners lose the right to sue they invest more in safety and this investment generates additional data from which the FAA can create additional advisories. An alternative explanation is that the FAA, suspecting that manufacturers will invest less if safety following a move from strict liability to no liability, increases its oversight. As a rule, however, the FAA does not inspect general aviation aircraft unless there is an accident and our regression includes the number of accidents in the consumption group in the previous year so this seems less likely than the former alternative. To provide further evidence on which of these stories best fits the data we turn to Service Difficulty Reports (SDRs). Unlike Airworthiness Directives, SDRs are provided by aircraft owners or their mechanics and are not generated by the FAA.

The SDR model is estimated use OLS and a specification similar to that for the Airworthiness Directives regression. The unit of observation is again the manufacturer-model and year manufactured. The results are contained in column 2 of Table 4. Again an increase in the size of the cohort moved off liability has a positive and significant impact on the number of SDRs. A one standard deviation increase in the number of aircraft moved off liability increases the number of SDRs by 8.68.

Additional evidence on the role of consumption externalities can be found in the market for used aircraft. If the move from strict liability to no liability generated an increased investment in safety by aircraft owners we would expect those aircraft in which larger numbers of aircraft move off liability to experience an increase in price (or less of decrease). Using data from the Aircraft Bluebook we estimate the impact of the law change on the value of an aircraft. The unit of observation is the same as the AD regression and the SDR regression. The model estimated is

$$\ln(Price_{it}) = \beta_1 N_i * P_{it} + \beta_2 N_{it} + \alpha_1 x_{it} + \gamma_t + \delta_i + \varepsilon_{\text{it}} \qquad (6)$$

where $\ln(\text{Price}_{\text{it}})$ is the log of the price in 2003 dollars.

In column (3) of Table X we present the results of the specification in (5). In column (6) we estimate equation (5) but include variables to control for whether the individual aircraft is over 18 and an interaction with over 18 and GARA. The coefficient on the interaction of the consumption group and the percentage without liability is positive and significant in both specifications. The coefficient in column (3) implies that a one standard deviation increase in cohort size produces a 2% increase in the price of an aircraft. Put another way moving one additional aircraft off liability increases the value of all the other aircraft in that manufacturer-model group by about $4.20.

4.3 Evidence of Increased "Victim" Precaution

Ideally we would like to directly observe the number of inspections or other safety behaviors induced by the change from strict liability to no liability. Data on one behavior, flying in daylight hours rather than at night is contained in the GAATA survey. We construct a ratio of daylight flight to total fight hours from the survey and estimate the impact of moving off strict liability. The bilateral precaution model predicts that this move should decrease risky behavior by those aircraft not covered by liability.

$$\%day = \beta_1 \text{GARA*Over\_18} + \beta_2 \text{Over\_18} + \beta_2 \text{GARA} + \alpha_1 x_{it} + \varepsilon_{\text{it}} \qquad (7)$$

where GARA is equal to one after GARA comes into effect, Over_18 equals one for aircraft over 18 and x_{it} is the set of control variables including the log of aircraft age, the approved uses for the aircraft and the ownership of the aircraft. In addition we add year fixed effects, year and year manufactured fixed effects and finally manufacturer-model (consumption group) fixed effects. The standard errors are clustered on the manufacturer-model and year which the unit of observation of the GAATA survey. As mentioned above one important limitation of the data is the fact that the survey's information by manufacturer-model ends in 1996. Although this is only two years after GARA's introduction it is potentially enough time to pick up behavioral changes.

The results are contained in Table 5. In all four specifications we find a positive and significant impact of moving from strict liability to no liability. In each case the impact is about a 4% increase in the likelihood that an aircraft is flown during the day.

Other data on flight behavior is not collected by the FAA or the NTSB unless there is an accident. Investigating safety behaviour and accidents is tricky if behaviour contributes to the accident. We focus, therefore, on a subset of behaviors are unlikely to cause an accident but still tell us something about safety.

We estimate a difference in difference model for three variables contained in the crash investigation data: the likelihood that an aircraft involved in a crash was inspected within the last 5 years, whether the crew was instrument rated and whether the pilot was wearing a seatbelt. The first is the least likely to fit our criteria in that one would hope that inspections would prevent accidents. Nevertheless 87% of accidents are due to pilot error not to issues that could be discovered in an inspection so the proportion of aircraft inspected may still reveal useful information. The results indicate that the probability that an aircraft was inspected in the last 5 years increased by 3.5% after GARA was implemented. Similarly, the probability that the crew of an aircraft was instrument rated rose rose by 2.3%.

Perhaps most relevant is the results on the probability that a pilot wears a seatbelt. Wearing a seatbelt is not likely to cause or prevent an accident but it does increase safety. We find that the probability a pilot involved in an accident was wearing a seatbelt rose by 1.9% after GARA.

Thus the evidence from Airworthiness Directives, Service Difficulty Reports, and our three measures of safety behaviour are all consistent with increased investments in safety by consumers post-GARA. The evidence on accidents shows that the result of these increases in investment were decreases in accidents that were larger the larger the consumption group. The evidence on prices is also consistent with an increase in safety.

5. Conclusion

When product risk is revealed through use consumption creates a positive externality for others consuming the same product. In the case of pharmaceuticals, for example, the risks associated with a drug and perhaps methods of reducing the risk are likely to become better known as more consumers use the drug. In this paper we examine one such positive externality in consumption, the more aircraft in a consumption group the lower the accident rate. We distinguished the consumption externality from consumer choice by examing what happened to accidents the 1994 General Aviation Revitalization Act limited the right to sue manufacturers and thus increased the incentive for consumers to invest in safety. We find that increased investment in safety has a larger impact when aircraft belong to a larger consumption group. An increase in the consumption group of 1000 aircraft reduces the likelihood of an accident in a given year by .6%. We also find that consumers value this positive externality at about $4.20 per additional aircraft in the relevant consumption group.

References

Berry, Steve and Joel Waldfogel (2003) “Product Quality and Market Size” NBER Working Paper 9675.

Bresnahan, T. and P. Reiss (1991): “Entry and Competition in Concentrated Markets,” *Journal of Political Economy*, 99, 977–1009.

Craig, Andrew (1991) “Product Liability and Safety in General Aviation,” in *The Liability Maze: The Impact of Liability Law on Safety and Innovation*, ed. Peter Huber and Robert Litan.

Dharmapala, Dhammika, Sandy Hoffman and Warren Schwartz (2001) “A Neglected Interdependency in Liability Theory.” Resources for the Future Discussion Paper 01-13.

Dixit, A and Joseph Stiglitz (1977): “Monopolistic Competition and Optimum Product Diversity,” *American Economic Review*, 67, 297–308.

Federal Aviation Administration (2003) *Best Practices Guide for Maintaining Aging General Aviation Airplanes.*

General Accounting Office (2001) *General Aviation: Status of the Industry, Related Infrastructure and Safety Issues.*

General Accounting Office (1991) *Aviation Safety: Progress Limited With Self-Audit and Safety Violation Reporting Programs.*

General Accounting Office (1989) *Aging Aircraft: FAA Needs Comprehensive Plan to Coordinate Government and Industry Actions.*

General Aviation Manufacturers Association, (1996) *Report to the President and Congress: The Results of the General Aviation Revitilization Act*.

George, Lisa and Joel Waldfogel (2003) “Who Affects Whom in Daily Newspaper Markets?” *Journal of Political Economy*

Gilligan, Thomas (2004) “Lemons and Leases in the Used Business Aircraft Market,” *Journal of Political Economy*. 112(5):1157-1180.

Jenkins, Stephen P. (2005) *Survival Analysis*, memo.

Katz, Michael and Carl Shapiro (1994) “System Competition and Network Effects,” *Journal of Economic Perspectives*, 8(2):93-115.

Landes, William M. and Richard A. Posner (1987). *The Economic Structure of Tort Law*. Cambridge, MA: Harvard University Press.

Lichtenberg, Frank and Joel Waldfogel (2002) “Does Misery Love Company? Evidence from Pharmaceutical Markets before and After the Orphan Drug Act” Mimeo. The Wharton School.

Manski C. and D. McFadden, (1981) "Alternative Estimators and Sample Designs for Discrete Choice Analysis". in *Structural Analysis of Discrete Data*. Editors C. F. Manski and D. McFadden. Cambridge, Massachusetts, M.I.T. Press.)

Martin, Robert (1991) “General Aviation Manufacturing,” in *The Liability Maze: The Impact of Liability Law on Safety and Innovation*, ed. Peter Huber and Robert Litan.

Priest, G. (1991) “The Modern Expansion of Tort Liability: Its Sources, Its Effects and Its Reform.” *Journal of Economic Perspectives*

Rodriguez, James F. (2005) “Tort Reform & GARA: Is Repose Incompatible with Safety?” *University of Arizona Law Review* 47: 577-606.

Schwartz, Victor E. and Leah Lorber (2002) “The General Aviation Revitalization Act: How Rational Civil Justice Reform Revitalized An Industry.” *Journal of Air Law and Commerce* 67:1267-1341

Shavell, Steven (1986) “The Judgment Proof Problem,” *International Review of Law and Economics*, 6(1):45-58.

Shavell, Steven (1987) *Economic Analysis of Accident Law*. Cambridge, MA: Harvard University Press.

Spence, A. Michael (1976) “Product Selection, Fixed Cost, and Monopolistic Competition,” *Review of Economic Studies*, 43:217-35

Waldfogel, Joel (2003) “Preference Externalities: An Empirical Study of Who Benefits Whom in Differentiated Product Markets” *RAND Journal of Economics*

Figure 1: General Aviation, 1946-2002, Accident Rate, Fatal Accident Rate and Liability

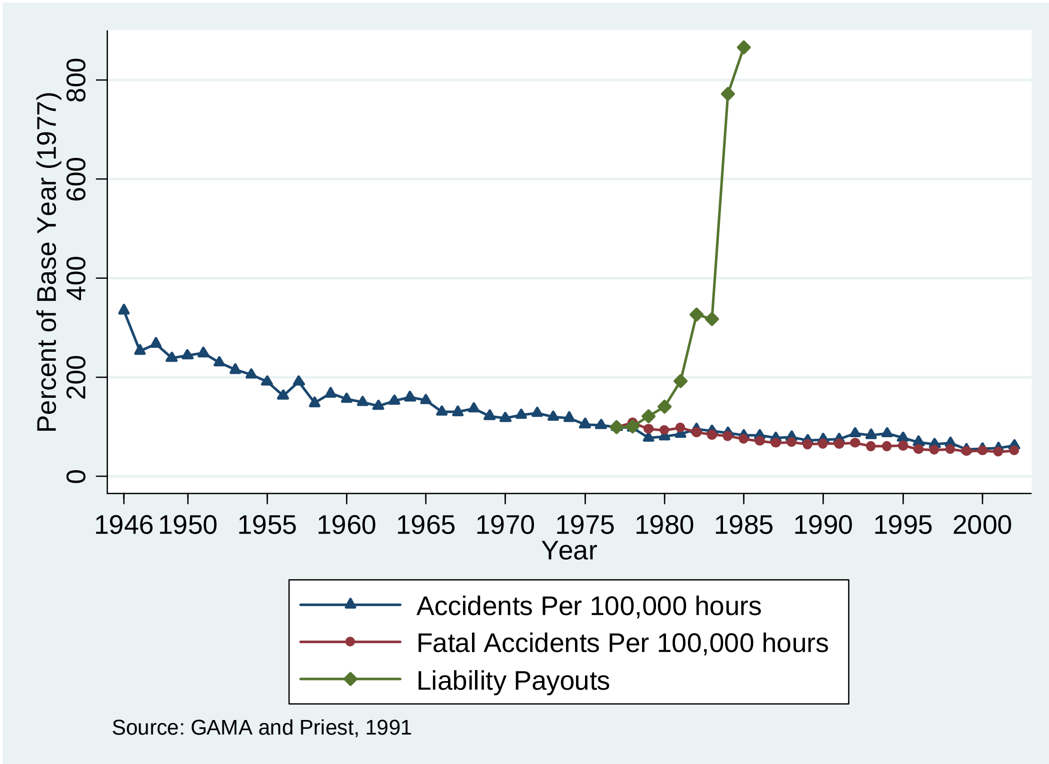

Figure 2: Production of General Aviation Aircraft 1980 to 2004

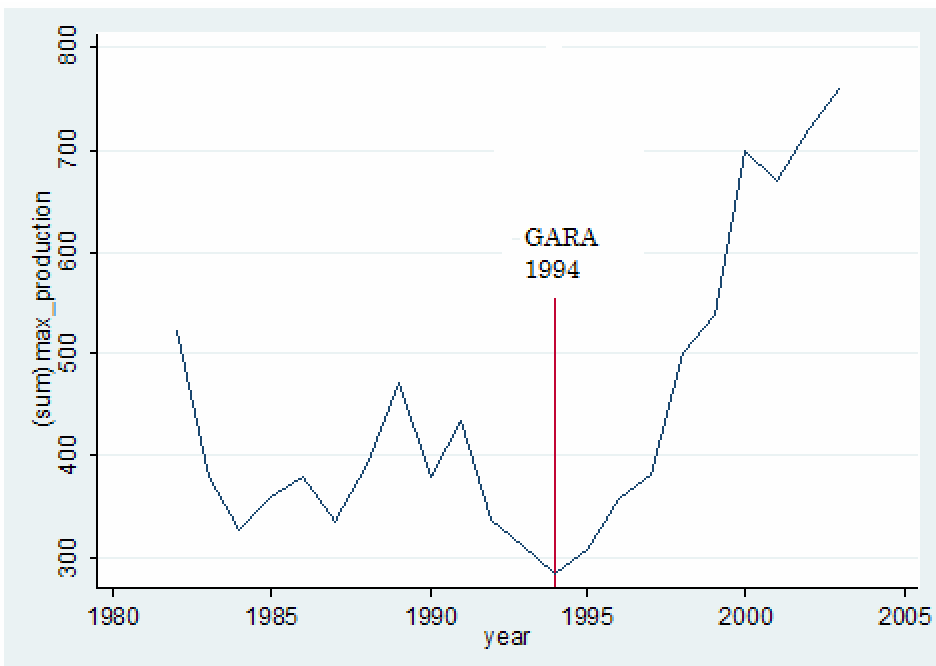

Figure 3: The proportion of aircraft without liability 1980-2003

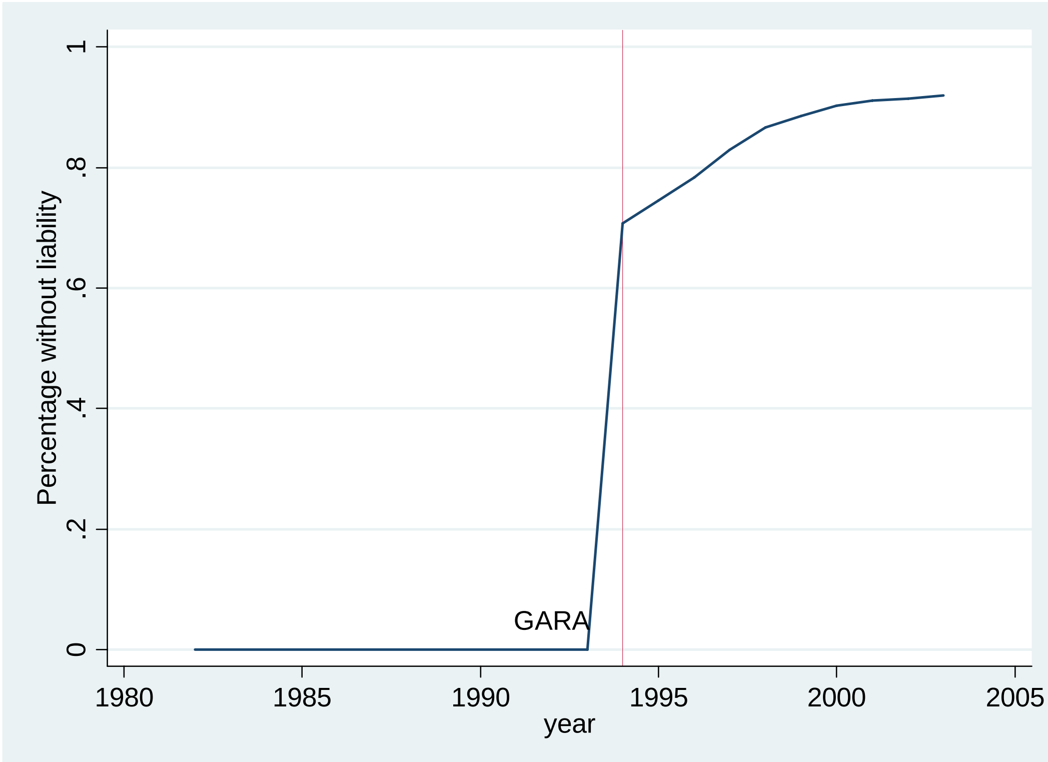

Table 1 Descriptive Statistics

Variable	Mean	Std.Dev.	Min	Max
Accident in year t	.1098958	.3127602	0	1
Number Aircraft by Manufacturer /Model in 1000s	3.039176	6.203615	0	23.55016
Manufacturer /Model in cohort 1000s	8.778128	9.334774	.001	27.065
Number of Aircraft * Active Company	8.568723	9.495817	0	27.065
Active Company	.8166917	.3869195	0	1
Post GARA* over 18	.3452789	.4754597	0	1
Over 18	.6098532	.4877836	0	1
Log Hours Flown	-127.4866	616.1111	-7640.178	28.10683
Percent Active	.6653972	.2195312	0	1
Log Age	3.0233	.7063066	0	4.219508
Approved for commuter use	.0172881	.130343	0	1
Approved for utility use	.0949782	.2931852	0	1
Approved for agriculture	.0474415	.2125815	0	1
Approved for surveying	.0022002	.0468544	0	1
Approved for advertising	.0035108	.0591476	0	1
Approved for weather monitoring	.0005488	.0234199	0	1
Approved for Research and Development	.0028617	.0534186	0	1
Approved for Exhibition	.0090788	.0948495	0	1
Commercial Flight	.1792412	.3835547	0	1
Partnership	.0331705	.1790817	0	1
Corporate Ownership	.2850398	.451434	0	1
Co-Owned	.1230442	.3284883	0	1
Government Owned	.0106475	.1026361	0	1

Table 2: All Accidents 1982-2003

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of Aircraft without Liability 1000	-0.00639**	-0.00524*	-0.00663**	-0.00568**	-0.04011	-0.06589**			-0.00562**	-0.00577**
	(0.00270)	(0.00270)	(0.00272)	(0.00272)	(0.02747)	(0.02799)			(0.00266)	(0.00272)
Number Aircraft in 1000s	-0.00267		-0.00261		0.05748***		-0.00049		0.00115	
	(0.00180)		(0.00180)		(0.01400)		(0.00167)		(0.00182)	
This Aircraft over 18 and Post GARA			0.06490	0.08075			0.06215	0.07693	0.06657	0.08341
			(0.06217)	(0.06277)			(0.06213)	(0.06258)	(0.06224)	(0.06281)
This Aircraft over 18 years old			0.00275	0.01423			0.00584	0.00821	0.01324	0.01438
			(0.04003)	(0.04000)			(0.04001)	(0.04012)	(0.04006)	(0.04011)
Number of Aircraft * Inactive Company							-0.16088***	-0.02993	-0.15981***	-0.02695
							(0.02565)	(0.04096)	(0.02566)	(0.04103)
Company still producing aircraft							-0.57242***	-0.25415**	-0.57013***	-0.25315**
							(0.04919)	(0.12041)	(0.04919)	(0.12066)
Number of Aircraft without Liability * Years since model first built					0.00079*	0.00094*				
					(0.00047)	(0.00048)				
Number Aircraft * Years since model first built					-0.00099***	0.00042				
					(0.00029)	(0.00042)				
Years since model first built					-0.01959***	0.00130				
					(0.00186)	(0.02746)				
Log Hours Flown	-0.00000	0.00018***	-0.00000	0.00018***	0.00001	0.00018***	0.00004***	0.00019***	0.00004***	0.00019***
	(0.00001)	(0.00006)	(0.00001)	(0.00006)	(0.00001)	(0.00006)	(0.00001)	(0.00006)	(0.00001)	(0.00006)
Percent Regularly Flown	-0.22651***	0.46102***	-0.22456***	0.46790***	-0.16239**	0.46301***	-0.03857	0.48992***	-0.05874	0.45959***
	(0.08017)	(0.09038)	(0.08033)	(0.09085)	(0.08053)	(0.09050)	(0.07853)	(0.09043)	(0.07898)	(0.09108)
Log Age	0.22008***	0.25966***	0.24276***	0.28724***	0.23539***	0.25843***	0.24737***	0.28533***	0.24757***	0.28562***
	(0.04208)	(0.04208)	(0.04715)	(0.04704)	(0.04220)	(0.04207)	(0.04710)	(0.04709)	(0.04714)	(0.04710)

chi squared test:	12.83		14.17	6.15	159.07	10.97	146.87	7.41		
Prob > chi_2	0.00		0.01	0.10	0.00	0.03	0.00	0.12		
Includes Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Includes Use Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Includes Year Manufactured Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Includes Manufacturer/Model Fixed Effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Robust standard errors on aircraft in parentheses clustered
* significant at 10%;
** significant at 5%;
*** significant at 1%
Observations 366446
Number Aircraft 20,000

Table 3: Means and standard deviations for data used in the Robustness Checks

Variable	Obs	Mean	Std.Dev	.Min	Max
Number of airworthiness directives	23306	.3689608	.9823656	0	20
Number SDRs	115337	5.244275	41.22662	0	3771
Price (2003 dollars)	37766	1268366	3275845	9655.245	4.49e+07
Number of Aircraft without Liability 1000	118605	.6202093	2.419608	0	23.55016
Number Aircraft by Manufacture/Model in 1000s	118605	1.542219	3.8888	.001	27.065
% Over 18 in Manufacture Model cohort	118605	.6144595	.3999756	0	1
Over 18	118605	.6219299	.4849073	0	1
Post GARA*Over 18	118605	.3444711	.4751975	0	1
Log Hours Flown	118605	-903.5544	1499.091	-7640.178	28.10683
Percent Active	118605	.5745593	.2102818	0	1
Lag Accident Rate	112396	.3528417	1.478114	0	76
Aircraft Age	118605	25.67202	15.7951	0	67

Table 4: Other Evidence

	(1) Airworthiness Directives	(2) SDR	(3) Log(price)	(4) Log(price)
Number of Aircraft without Liability 1000	0.04069***	0.14370***	0.00332***	0.00266***
	(0.00876)	(0.05067)	(0.00091)	(0.00083)
Log Hours Flown	0.00013***	0.00112***		-0.00004***
	(0.00003)	(0.00042)		(0.00001)
Percent Active	0.59495***	-0.01159		-0.05387***
	(0.08496)	(0.60443)		(0.00920)
Total number of accidents for the manufacturer/model in the previous year	0.06320***	0.27692***		-0.00269
	(0.01934)	(0.09975)		(0.00164)
Aircraft age	-0.04028***	0.11147***		0.00151***
	(0.00563)	(0.02668)		(0.00043)
Number Aircraft by Manufacture/Model in 1000s			-0.03748***	-0.02104**
			(0.00934)	(0.00865)
% Over 18			-0.20592***	-0.21490***
			(0.00798)	(0.00755)
Observations	20598	117799	37766	35826
Number of manufacturer/Model groups	1167	6451	2399	2394
R-squared		0.02	0.07	0.07

Standard errors in parentheses clustered on manufacturer-model
* significant at 10%;
** significant at 5%;
*** significant at 1%

Table 5 Percentage of Daylight Hours Flow 1982-96

	(1) Hours Flow During Day	(2) Hours Flow During Day	(3) Hours Flow During Day
Post GARA * Over 18	0.04770**	0.04156*	0.04042**
	(0.01856)	(0.02449)	(0.01758)
Over 18 years	-0.01147	-0.00324	-0.02150**
	(0.01638)	(0.02301)	(0.00893)
post_gara	0.00503	0.29318**	0.37393***
	(0.01771)	(0.12508)	(0.08362)
Log Age			0.03644
			(0.02290)
Observations 14608			
Robust standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

Table 6

	(1) Aircraft Inspected in last 5 years	(2) Pilot wearing seatbelt	(3) Crew Instrument Rated
Post GARA * Over 18	0.03401***	0.01923**	0.02359***
	(0.01007)	(0.00923)	(0.00691)
Over 18 years	0.08240***	0.10895***	-0.02308***
	(0.00553)	(0.00506)	(0.00379)
Post GARA	0.06914***	0.04988***	0.01967***
	(0.00811)	(0.00744)	(0.00557)
Observations 43855			
Standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			