THE JOURNAL OF INDUSTRIAL ECONOMICS 0022-1821
Volume L June 2002 No. 2

WHO INITIATES RECALLS AND WHO CARES? EVIDENCE FROM THE AUTOMOBILE INDUSTRY*

NICHOLAS G. RUPP† AND CURTIS R. TAYLOR‡

In this paper, we investigate two questions. First, we explore which entity (the NHTSA or the manufacturer) is more likely to initiate a given auto safety recall campaign. Second, we analyze the determinants of owner response rates to safety recalls. Our data spans nineteen years (1980–1998) for the six largest auto manufacturers. We find evidence that the government initiates larger, less hazardous recalls involving older models and financially weak firms. Inexpensive recalls are more likely to be manufacturer initiated. The largest owner repair responses are associated with newsworthy hazardous defects of new domestic vehicles in their inaugural model year.

'The sole function of an automobile is not just to provide a means of transportation, it is to provide a means of safe transportation, or as safe as is reasonably possible under the present state of the art' (U.S. Court of Appeals, Eighth Circuit, 1968, writings for: *Larsen vs. General Motors Corporation*).

I. INTRODUCTION

A RECENT JURY DECISION ordered General Motors to pay $4.9 billion to six people burned when their fourteen year old 1979 Chevrolet Malibu fuel tank ruptured. The case centered on GM's failure to redesign or recall an allegedly known faulty fuel system (*Wall Street Journal*, July 12, 1999). Neither GM nor the National Highway Traffic Safety Administration (NHTSA) had (or have) initiated a recall for this model. The California court case begs the question: who initiates a recall? We offer an answer in the pages that follow.

*We thank Hae-Shin Hwang, Dong Li, Matt Neideffer and participants in the seminar series at Virginia Commonwealth University for helpful comments and suggestions. Support from the Bradley Fellowship of the Private Enterprise Research Center is gratefully acknowledged, as is support from the National Science Foundation (grant SBR 9810858) and the Jordan Professorship of the Private Enterprise Research Center at Texas A&M University.

†Authors' affiliations: Department of Economics, East Carolina University, A-427 Brewster Building, Greenville, NC 27858-4353, USA.
email: ruppn@mail.ecu.edu

‡Department of Economics, Duke University, Durham, NC 27708-0097, USA.
email: crtaylor@econ.duke.edu

In this paper, we investigate the recall process with respect to both firm and government behavior. Using nineteen years of NHTSA data from 1980 to 1998, we find evidence that the government initiates larger, less hazardous recalls involving older models and financially weak manufacturers. Firms are more likely to initiate inexpensive recalls in the form of a placard mailing or a third-party equipment replacement. In addition, by using a database that spans a longer period, we present new evidence that hazardous defects for new domestic vehicles generate larger owner repair responses. We also demonstrate that publicized recalls and defects involving inaugural model year vehicles have significantly higher repair rates.

Automobile recalls have been studied extensively over the past two decades. For instance, several researchers have used event studies to analyze the equity market response to recall announcements. The pioneering work by Jarrell and Peltzman [1985] finds significant shareholder losses due to automobile recalls.[1] Others have examined the effect of recalls on both new and used vehicle sales.[2] Garber and Adams [1998] investigate how recalls influence product liability verdicts against auto manufacturers.[3]

The present paper is the first work, to our knowledge, to investigate which entity (the manufacturer or the government) initiates a given recall. The crux of our story rests on the premise that it is costly for either the firm or the government to determine whether a given vehicle should be recalled. Given this, the government optimally 'stretches' its limited budgetary resources by leaving the firms to investigate the most obvious recall candidates. Hence, the safety agency tends to initiate more 'marginal' recalls involving less serious defects.

We use NHTSA data to test this basic hypothesis. We also estimate the probability of government-initiated recalls for a subset of widely publicized recall announcements (i.e., those appearing in the *Wall Street Journal* (WSJ)). This specification allows for a better measure of the recall hazard since the WSJ typically reports defect-related injuries, accidents, and fires (data not reported by NHTSA). Additionally, this enables us to examine the effect of injuries and accidents on firm, government, and consumer actions. Our investigation considers the attributes of well

[1] Re-examining the data, Hoffer, Pruitt and Reilly [1988] report little support for the Jarrell and Peltzman findings. For more recent studies on the equity effects of recalls see Barber and Darrough [1996]; and Rupp [2001].

[2] For the effect of recalls on new car sales see Crafton, Hoffer, and Reilly [1981]; and for used cars Hartman [1987].

[3] For additional studies on product liability effects in the automobile industry see Huber and Litan [1991]; and Hunziker and Jones [1994]. For theoretical work on product recalls see Welling [1991] and Marino [1997].

publicized recalls;[4] what role the media plays in the initiation of recalls; and, the response of owners to these high profile campaigns.

On the subject of owner-response rates to recall campaigns, Hoffer, Pruitt, and Reilly [1994], using 1984–86 NHTSA data, find that recalls involving domestic, recent model vehicles with severe safety defects generate the largest rates of repair. Our paper employs both NHTSA and WSJ recall data spanning nineteen years to re-examine this question. The advantage of using the WSJ data is the ability to investigate the effects of injuries, accidents, and fires on recall responses by owners. It is, of course, important to understand what drives owner response rates to recall campaigns because the ultimate objective of recalls is to repair as many defective cars as possible. With a better understanding of what influences owner responses, the NHTSA could modify the current notification program to increase future correction rates, resulting in improved vehicle safety. For example, since issuing a safety defect press release is currently optional, if publicly announced recall campaigns generate a large owner response, NHTSA could consider mandating recall announcements.

To summarize, we attempt to answer two questions in this paper: first, why are some recalls initiated by firms and others launched by the government; and second, which recall campaigns generate the largest owner responses in repairing defective vehicles. In the next section, we review the automobile safety recall process. Section III contains a discussion of the data. In Sections IV and V we take up the questions at the heart of this study. We summarize and offer a few closing remarks in the conclusion.

II. THE RECALL PROCESS

In an effort to increase motor vehicle safety, on September 9, 1966, Congress passed the National Traffic and Motor Vehicle Safety Act of 1966 (15 U.S.C. 1381). The Act required the Secretary of Transportation to establish safety standards for motor vehicles and vehicle equipment to reduce traffic accidents, injuries, and fatalities. The Secretary created a new agency, the National Highway and Traffic Safety Administration (NHTSA), whose responsibilities include: (1) establishing minimum federal safety performance standards for motor vehicles and equipment; (2) verifying that motor vehicles and equipment satisfy the safety standards; (3) investigating possible motor vehicle safety noncompliance; and (4) in situations of noncompliance, directing recall campaigns to

[4] Garber and Bower [1999] contend that higher media coverage occurs for automotive product liability verdicts which favor the plaintiff especially in cases involving large punitive damage awards.

ensure all vehicle and equipment comply with safety standards (GAO/RCED-90-56).

The Safety Act of 1966 places the burden of conforming to standards directly on manufacturers.[5] Once a manufacturer has knowledge that the vehicle or equipment fails to comply with federal safety standards then they must notify the NHTSA, vehicle owners, and dealers of the existing defect. Furthermore, the manufacturer must offer a remedy (at no cost to the owner) that brings the vehicle or equipment into compliance. In the event of a recall, manufacturers are required to contact the owner via first-class mail; however, they are not required to issue a press release announcing the defect. Manufacturer notifications of forthcoming recall campaigns are publicly posted in the NHTSA Technical Information Services Reference Library (Room 5110) in Washington, DC.

Since its inception in 1966 until 1998, the NHTSA has overseen 6,862 recalls involving more than 248 million vehicles. Almost all of these recalls are considered 'voluntary' since the manufacturer agrees to conduct a recall overseen by NHTSA. Rarely are recalls ordered by NHTSA since this action requires a lengthy court battle which damages the image of both parties involved.[6] Only eight times since the safety agency was founded has NHTSA sued car makers for alleged safety defects (*Wall Street Journal*, June 5, 1996).

Voluntary recalls can be initiated by either the NHTSA or the manufacturer.[7] In the first case, the safety agency notifies the manufacturer when a trend develops in consumer complaints[8] marking the beginning of a preliminary investigation. From this point the investigation follows one of three routes: closed (51.6%), escalated (37.9%), or recalled (10.5%). Investigations are closed when there is no apparent violation of the safety standard. Should the preliminary investigation merit further review (on

[5] Section 113(a) of the 1966 Safety Act requires: 'Every manufacturer of motor vehicles shall furnish notification of any defect in any motor vehicle or motor vehicle equipment produced by such manufacturer which he determines, in good faith, relates to motor vehicle safety, to the purchaser (where known to the manufacturer) of such motor vehicle or motor vehicle equipment, within a reasonable time after such manufacturer has discovered such defect'.

[6] For example, the most recent government-ordered recall involved 91,000 1995 Chrysler Cirrus and Dodge Stratus models which had alleged rear seat belt safety problems. The lawsuit began on June 4, 1996. More than two years later, on October 30, 1998, a Federal Appellate court sided in favor of Chrysler and overturned the NHTSA recall order (*Wall Street Journal*, November 2, 1998).

[7] The term initiate indicates which party (manufacturer or NHTSA) initiates the safety investigation that resulted in a recall. The NHTSA classifies recalls as government initiated if the NHTSA has begun an investigation into the safety defect (regardless of whether the NHTSA has concluded its investigation). On the other hand, recalls are classified as manufacturer initiated if the NHTSA has not opened a safety investigation.

[8] Consumers call the National Highway Traffic Safety Administration's Auto Safety Hotline (1-888-DASH-2-DOT) to register their complaint.

average 140 days later), NHTSA escalates to an engineering analysis (again posted in the Reference Library). This stage consists of vehicle testing by NHTSA and takes approximately one year to complete (on average 357 days).

Laboratory testing determines if the vehicle and equipment comply with Federal motor vehicle safety standards. Approximately one-third of the tests (35.2%) reveal non-compliance in which case the manufacturer is asked to issue a recall, and two-thirds of the tests (64.8%) find a compliant vehicle which closes the investigation.[9] At any point during the safety review process, the manufacturer can issue a recall, which halts the investigation. In approximately ten percent of the preliminary investigations, the manufacturer issues a recall before the investigation reaches the testing phase. In the second case, a manufacturer initiates a recall after collecting information from four sources: (i) quality control personnel during production; (ii) consumer complaints at the dealership; (iii) consumer complaints sent directly to corporate headquarters; and, (iv) consumer complaints to NHTSA (which are forwarded to the manufacturer). The manufacturer pays all costs associated with the recall.

III. DATA

III(i). *The Sample*

Recall data spanning the years 1980 to 1998 were obtained from three sources: the NHTSA web site,[10] the *Wall Street Journal (WSJ)*, and *Moody's Bond Record*. The NHTSA database includes every U.S. motor vehicle safety recall regardless of who initiated the campaign. Between 1980 and 1998 there were a total of 3,918 safety recalls for 168 million vehicles.[11] Many of the recalls, however, involved only a small number of vehicles. For instance, 587 of the 3,918 recalls affected fewer than 100 vehicles. Of these, eighty percent (470 of 587) are manufacturer-initiated. To prevent an over weighting of recalls from the largest manufacturers and due to an overwhelming number of small recalls the following selection criteria was used to determine the sample. First, vehicle recalls must exceed one percent of the current calendar year car and light truck unit sales.[12] During the 1980s and 1990s all major auto makers with the

[9] Preliminary investigation and engineering analysis figures cover 1980–1998 for Chrysler, Ford, General Motors, Nissan, Toyota, and Honda. Incomplete investigations are omitted.

[10] ftp://www.nhtsa.dot.gov/recall.

[11] The sample does not include emissions related recalls administered by the Environmental Protection Agency.

[12] The 1997 minimum threshold for vehicle recalls for Chrysler, Ford, and GM is 23,038, 37,807, and 47,035, respectively. Likewise, the cut-off for Honda, Nissan, and Toyota is 9,404, 7,284, and 12,301 vehicles.

exception of GM experienced tremendous growth in unit sales.[13] Thus, a relative recall standard (such as one percent of yearly sales) is preferred to an absolute threshold. Second, the sample is limited to the six largest manufacturers of cars and light trucks, which held a combined 90.4 percent U.S. market share in 1997 (*Ward's Automotive Yearbook* 1998). Third, the recall must involve a vehicle or vehicle equipment (tire recalls are omitted). Descriptive statistics of the 479 recalls involving 133 million vehicles (79.2% of all recalled units) that satisfy the selection criteria are given on Table I.[14]

Slightly more than half of the sample (264 of 479) are manufacturer-initiated. The government initiates larger recalls, averaging 521,379 vehicles compared to 162,000 for the manufacturer. Domestic auto makers comprise approximately four-fifths (78.7%) of the observations. Chrysler has more recalls (111) than Honda, Toyota, and Nissan combined (102).[15]

We also consider a subsample of 285 'news-worthy' recall campaigns (i.e., those appearing in the WSJ). There are two reasons for studying this subsample. First, the WSJ is the main source of data used in the prior literature on auto recalls. Second, the WSJ includes three variables involving consumers' actual safety experiences not reported by NHTSA.

III(ii). *Variables*

The variables obtained from the NHTSA database are as follows:

- *Initiator* takes the value one if the NHTSA launched the recall and zero if the manufacturer did.
- *Percentage repaired* is the percentage of the defective vehicles corrected over the six quarters following a recall announcement.
- *High hazard* indicates that the recall received the most hazardous rating from NHTSA for potential safety problems (i.e., defects that could result in loss of vehicle control due to acceleration, steering or braking, frame corrosion, fire, or repeated stalling). Forty percent of the recalls in the sample received this rating.
- Auto makers are coded as one if they manufactured the vehicle and zero otherwise. *Vehicles recalled* (in 100,000s) represent the total number of units recalled. An interaction term: *manufacturer*vehicles recalled* indicates the firm specific effect for the number of vehicles recalled.

[13] For example, Honda, Chrysler, and Toyota registered 151 percent, 122 percent, and 111 percent increases in unit sales, respectively from 1980 to 1997.

[14] The sample also omits seven observations in which vehicle correction totals were not reported.

[15] Chrysler registered 31.9 million unit sales of cars and light trucks in the United States from 1980–1997 while Toyota, Honda, and Nissan combined for 40.3 million unit sales during the same time period.

TABLE I
AUTO RECALLS DESCRIPTIVE STATISTICS (IN THOUSANDS EXCEPT CAMPAIGNS), 1980–98

	Government Initiated Recalls			Manufacturer Initiated Recalls		
	Recall Campaigns	Vehicles Recalled	Std. Dev.	Recall Campaigns	Vehicles Recalled	Std. Dev.
Chrysler	57	276.3	281.6	54	114.1	125.4
Ford	64	868.3	2,787.3	65	138.1	146.6
GM	50	501.7	603.0	87	249.6	659.4
Honda	7	963.7	1,275.8	18	142.0	230.1
Nissan	22	230.7	581.6	21	116.6	181.7
Toyota	15	227.6	194.8	19	47.8	36.9
Total recalls	215	521.4	1,598.6	264	162.0	401.1
Nationality of Manufacturer						
United States	171	563.8	1,752.9	206	178.9	443.8
Japan	44	346.2	691.7	58	102.0	171.4

Categorical Variables	Total Campaigns	Total Percent*	Government Initiated	Manufacturer Initiated
High Hazard	192	40.1%	75	117
Placard/Equipment recalls	30	6.3%	3	27
Wall Street Journal	285	59.5%	137	148
WSJ & Accident	51	17.9%	35	16
WSJ & Injury	63	22.1%	53	10
WSJ & Fire	38	13.3%	21	17
Inaugural model	63	13.2%	26	37
High bond rating	54	11.3%	19	35
Current year model	194	40.5%	37	157
One & two year old model	149	31.1%	67	82
Three+ years old model	136	28.4%	111	25

* Total Percent is total campaigns divided by 479; *WSJ* & variables are divided by 285.

- *Placard/equipment recall* proxies inexpensive recalls by indicating situations where an information placard (in lieu of a physical repair) is mailed to owners explaining possible safety hazards or equipment recalls are conducted. Placard recalls involve only the cost of first-class postage. Equipment recalls commonly involve a third party that agrees to reimburse the auto maker for recall-related costs.
- Vehicle age is a categorical variable. *Current year model* equals one for recalls involving new models (40.5% of the sample) and zero otherwise. Likewise, *one & two year old model* equals one when the vehicles recalled are one or two model years old (e.g., in 1998, Ford recalls 1996 and 1997 Escorts) and zero otherwise. The *three+ years old model* denotes recalled models that are at least three years old (28.2% of the sample) and zero otherwise. Finally, for the recalls that overlap two or more of

the above categories, each dummy variable is assigned its share of the recalled units.[16]

- The interaction term *three+ years old model*vehicles recalled* is zero if the recall involves models less than three years old and equals the number of units recalled otherwise.
- *Inaugural model year* equals one for models in their introductory year of production.

The three recall variables gleaned from the WSJ are as follows:

- *Fire* indicates whether defect-related fires were reported.
- *Accident* indicates whether defect-related accidents were reported.
- *Injury* indicates whether defect-related injuries were reported.

Finally, *Moody's Bond Record* was used to construct the variable *high bond rating* which equals one for corporate bonds receiving the highest or second highest quality rating by Moody's (Aaa and Aa1 which comprise 11.3% of the sample) and zero otherwise. Bond ratings were not available in the early 1980s for Japanese auto makers since these companies did not issue corporate bonds until the mid-1980s. To prevent a loss of thirty-four observations, we used debt-to-equity ratios to forecast bond ratings for the Japanese firms during this period.

In the ensuing two sections, we use these data to address the questions posed in the Introduction. Specifically, in the next section we investigate which entity (the NHTSA or the manufacturer) is most likely to initiate a given recall and in the subsequent section we explore the determinants of recall response rates by owners.

IV. WHO INITIATES A RECALL?

In the following two subsections, we present and test three hypotheses regarding the likely initiator of a given recall campaign. All of the hypotheses are consistent with either of two possible models each of which has its own merits. We summarize both of them here.

Story 1: The NHTSA and the manufacturer are initially symmetrically informed regarding the pattern of consumer complaints and reported injuries. Each entity must decide which set of complaints to investigate. It is typically not optimal to investigate all complaints since investigations are costly to perform. The NHTSA moves first in the *investigation game*, and the manufacturer moves second. Let S be the set of consumer complaints (i.e., the set of possible defects) and let $M \subset S$ be the subset of complaints that the manufacturer has incentives to investigate on its own. In general, M will consist of those possible defects that assign the

[16] We thank the editor, Severin Borenstein, for suggesting this.

highest potential liability to the firm and that are the least expensive for it to fix. Since the government moves first in the investigation game, it will not investigate any complaints in M, knowing that the manufacturer will do so. Rather, the NHTSA will investigate the subset of complaints $G \subset \{S \setminus M\}$ that pose the highest safety concerns. In other words, G will be composed of the potential defects that the manufacturer would not investigate on its own (i.e., the ones that assign it relatively low potential liability and are costly for it to fix).

Story 2: The manufacturer initially possesses superior information concerning potential defects which it takes the government some time to learn. Specifically, the manufacturer initially knows S, but the NHTSA does not observe S until some time has elapsed. In this scenario, the manufacturer moves first in the investigation game, choosing the subset $M \subset S$ of potential defects to investigate. Once the government observes S and M, it chooses the subset $G \subset \{S \setminus M\}$ of potential defects to investigate. As in Story 1 (though for slightly different reasons), M will generally consist of those possible defects which assign the manufacturer high potential liability and are the least expensive for it to fix. The manufacturer will investigate these potential defects rather than run the risk of incurring substantial liability costs while waiting for the government to investigate them. Hence, G will generally consist of those potential defects that are somewhat less serious than those in M and/or that would be expensive for the manufacturer to fix.

Although the reasoning underlying these stories is somewhat different, both of them has some real-world appeal. The main formal difference is that in Story 1 the government acts strategically, and the firm optimally responds, while the reverse is true in Story 2. For the purposes of this paper, it does not matter which story (if either) is correct, since the main empirical implications are the same. We present these formally in the next subsection and test them subsequently.

IV(i). *Hypotheses*

In this subsection, we present three simple hypotheses concerning the likely initiator of a recall.[17] Given our data, it is possible to test only one of these hypotheses directly (Claim 1). It is, however, possible to provide some fairly compelling indirect evidence for the other two hypotheses.

[17] Claims 1 and 2 presented here and Claim 4 of the following section have been derived theoretically in a formal model. Because the predictions of the model are straightforward and because it is notationally cumbersome, the editor asked that we conserve space by resorting to a less formal discussion. See the *Journal*'s editorial Web site for further details about the formal theoretical results.

Claim 1: NHTSA is less likely than the manufacturers to initiate recalls involving the most serious safety defects.

The reason behind this somewhat paradoxical prediction is actually quite straightforward. Although NHTSA is charged with ensuring automotive safety, the products liability system already provides manufacturers with incentives to recall highly hazardous automobiles. In other words, the objective of the government and the manufacturers are fairly closely aligned in the case of severe safety problems. Since initiating a recall is costly and since NHTSA has a limited budget, it would be rational for the safety agency to employ its resources by initiating recalls that manufacturers might otherwise overlook. On average, these will be marginal cases involving less hazardous conditions.

Claim 2: NHTSA is more likely than the manufacturers to initiate recalls involving expensive repairs.

This prediction is straightforward. The safety agency's mandate is to protect the public from dangerous automobile defects regardless of the cost of correcting them. The objective of manufacturers, on the other hand, is profit maximization. Hence, we expect the NHTSA to be less cost sensitive than the manufacturers with regard to initiating recalls.

Claim 3: NHTSA is more likely than the manufacturers to initiate recalls which generate significant liability for the firms.

The key distinction here is between *ex ante* or *potential* liability and *ex post* or *actual* liability. Manufacturers possess significant incentives to recall cars early to avoid potential liability, but they will be more reluctant to recall older units since a significant number of injuries may have already occurred. While initiating a recall is not an admission of negligence by the manufacturer, it is a recognition of a product defect. If the manufacturer believes that the best way to avoid liability is to defend itself from personal injury claims in court, then it should be reluctant to weaken its case by initiating a recall. To the extent that NHTSA adheres to an objective safety standard, on the other hand, its decision to initiate a recall should not depend directly on pending liability claims against the manufacturers.

IV(ii). *Estimation*

We estimate the following bivariate probit model [Greene 2000]:

$$(1) \qquad Y^* = X\beta + \varepsilon_Y$$

$$R^* = X\alpha + \varepsilon_R \tag{2}$$

and $(\varepsilon_Y, \varepsilon_R) \sim BVN(0, 0, 1, 1, \rho)$. The latent variables Y^* and R^* indicate respectively the recall initiator and whether the recall was reported by the WSJ. The vector x contains the recall and vehicle characteristics discussed above, and β and α are parameter vectors.[18]

For the subset of Wall Street Journal recalls, we also estimate a standard probit model:

$$Prob(Y = 1) = \int_{-\infty}^{\beta' X} \phi(t)dt = \Phi(\beta' X) \tag{3}$$

where the function Φ denotes the standard normal distribution and $\phi(t)$ is the standard normal density. Since the X vector is comprised almost entirely of dummy variables (only *vehicles recalled* and *percent repaired* are continuous), the reported marginal effects indicate how a change in the dummy variable from 0 to 1 effects the mean value of the dependent variable.[19]

IV(iii). *Results*

Five variables were consistently significant in explaining the initiator. Table II summarizes our results concerning the recall initiator for the bivariate probit and probit equation coefficient estimates for all NHTSA recalls and for the subset appearing in the WSJ, respectively.[20] The z-statistics are based on White [1980] heteroscedastic-consistent standard errors. For the universe of NHTSA recalls, we find the relevant variables are *manufacturer*vehicles recalled, high hazard, placard/equipment recall* and *model year age*. For the widely publicized recalls: *high hazard, high bond rating, injury, model year age*, and *three+ years*vehicles recalled* yield significant explanatory power.

Considering first the universe of NHTSA recalls, we find direct support for Claim 1 as the coefficient on high hazard is significantly negative. In other words, the NHTSA is less likely than the manufacturers to initiate recalls involving the most serious safety problems.

Next, observe that vehicle manufacturers yield little explanatory power,

[18] The same sets of exogenous variables are used in (1) and (2) with one necessary exception; *placard/equipment* is excluded from the WSJ regression due to a lack of observations. Not surprisingly, such recalls are seldom news-worthy.

[19] For example, the probability of a government-initiated recall with $x_1 = 0$ is $\Phi(\hat{\beta}_0 + \hat{\beta}_2\bar{x}_2 + \ldots) = z_0$. For a recall with the same characteristics except $x_1 = 1$, the probability is $\Phi(\hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2\bar{x}_2 + \ldots) = z_1$. The difference $z_1 - z_0$ is the marginal effect of x_1.

[20] All regressions are conditional on an actual recall occurring, clearly not all unsafe cars are recalled due to randomness in the occurrence of product failures and consumer reporting and errors by NHTSA and the manufacturers.

TABLE II
PROBABILITY OF INITIATOR RECALLS

Model Sample	Bivariate Probit All		Probit Conditional on *WSJ*	
Variable	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Constant	−0.363	–	−0.114	–
	(−1.379)		(−0.312)	
Ford	0.071	0.073	−0.047	−0.018
	(0.303)		(−0.157)	
Chrysler	0.225	0.044	0.653	0.217
	(0.225)		(1.619)	
Toyota	−0.485	−0.003	0.092	0.034
	(−0.930)		(0.134)	
Honda	−0.430	−0.100	−0.815	−0.316
	(−0.968)		(−1.074)	
Nissan	0.443	0.089	0.678	0.219
	(1.535)		(1.810)	
Ford*Vehicles recalled	0.163	0.019	0.225	0.084
	(2.422)		(2.677)	
Chrysler*Vehicles recalled	0.171	0.047	−0.022	−0.008
	(1.995)		(−0.224)	
GM*Vehicles recalled	0.010	0.010	−0.010	−0.004
	(0.539)		(−0.598)	
Toyota*Vehicles recalled	1.048	0.116	0.409	0.153
	(2.612)		(0.927)	
Honda*Vehicles recalled	0.005	0.018	−0.098	−0.037
	(0.067)		(−0.826)	
Nissan*Vehicles recalled	−0.056	0.008	−0.316	−0.119
	(−0.751)		(−2.261)	
High hazard	−0.295	−0.088	−0.434	−0.163
	(−2.106)		(−2.237)	
Percent repaired	0.098	0.005	−0.017	−0.006
	(0.329)		(−0.039)	
Placard/Equipment recall	−0.754	−0.175	–	–
	(−1.975)			
High bond rating	−0.265	−0.076	−0.654	−0.255
	(−0.965)		(−1.878)	
Current year model	−0.941	−0.273	−1.072	−0.402
	(−4.529)		(−3.769)	
Three+ years old model	1.074	0.426	0.346	0.130
	(4.240)		(0.856)	
Three+ years*Vehicles recalled	0.062	−0.012	0.306	0.115
	(1.026)		(2.226)	
Inaugural model	0.326	0.073	0.236	0.089
	(1.648)		(0.948)	
Accident	–	–	0.438	0.154
			(1.604)	
Injury	–	–	0.621	0.213
			(2.154)	
Fire	–	–	0.093	0.034
			(0.324)	
Log likelihood	−480.21		−121.59	
Sample size	479		285	

Note: *z*-statistics, in parentheses, are based on White (1980) heteroscedasticity-consistent standard errors. *Placard/Equipment recall* is omitted from the probit estimation due to a lack of *WSJ* observations.

as no firm has a significantly different rate of government-initiated recalls than GM (the benchmark). A Wald test that the firm coefficients are jointly equal to zero cannot be rejected.[21] None of our hypotheses suggest that there should be a systematic difference between firms regarding their recall initiation rates, and this appears to be born out in the data. The NHTSA also appears to initiate recalls without regard to the nationality of the auto maker as we cannot reject the hypothesis that government initiation rates for the U.S. firms are equivalent to their Japanese counterparts.[22]

The government evidently initiates larger recall campaigns as the *manufacturer*vehicles recalled* is positive for every firm and significant for Ford, Chrysler, and Toyota. For example, recalling an additional 100,000 vehicles from the *Ford*vehicles recalled* mean increases the probability of a government-initiated recall by 1.9 percentage points as indicated on Table II. A Wald test that the coefficients on *manufacturer*vehicles recalled* are jointly equal to zero is easily rejected.[23] Manufacturers may be reluctant to initiate large recalls because they are more costly, although it is not possible to test this directly since the auto makers do not disclose recall costs. We conducted a likelihood ratio (LR) test to ascertain whether it is appropriate to include nonlinear volume effects (i.e., *Manufacturer** (Vehicles Recalled Squared) for each of the six auto makers).[24] Since we cannot reject the hypothesis that the nonlinear terms jointly equal zero, nonlinear dummies are excluded from the estimations.

One available cost proxy is *placard/equipment recall*. Placard 'recalls' involve no vehicle repairs. Instead, informational cards are mailed to car owners, which typically involve updating the owner's manual or a safety reminder on how to properly operate the vehicle. Equipment recalls are also inexpensive for auto makers as an outside equipment supplier typically pays the bill for these repairs. It is not surprising that manufacturers initiate significantly more inexpensive recalls. Specifically, a *placard/equipment recall* is 17.5 percent less likely to be government-initiated (or alternatively, manufacturers are 17.5 percent more likely to

[21] The $\chi^2(5) = 5.85$ with a p-value $= 0.3211$.

[22] Replacing the individual firms with *U.S. Big Three* in the bivariate probit estimation yields an insignificant coefficient of -0.016 (-0.076 z-statistic). See the *Journal*'s editorial Web site for further details about the estimation results which appear in the Appendix as Table AI.

[23] The $\chi^2(6) = 18.87$ with a p-value $= 0.0044$.

[24] The unrestricted model included these additional six nonlinear volume terms in the estimation of government initiated recalls, while these terms were excluded from the restricted model. See the *Journal*'s editorial Web site for further details about these results which appear in the Appendix as Table AII. This table reveals that the $LR = -2(-480.21 - 474.87) = 10.68 \sim \chi^2_6$ which is below the critical value of 12.59. We thank an anonymous referee for this suggestion.

initiate placard or equipment recalls). This, is perhaps, the strongest evidence supporting Claim 2.

Bond ratings are intended to capture the financial stability of the firm. Specifically, a proposition akin to Claim 2 is that financially weak firms should be less likely to initiate recalls than strong ones (i.e., financially weak firms should discount future expected liability claims more heavily). Unfortunately, for the full NHTSA sample of recalls we cannot reject the one-tailed test of the hypothesis ($H_0 : \beta_{High\ Bond} \geq 0$) that firms having a *high bond rating* are subject to more government-initiated recalls.[25]

The variable garnering the largest z-statistics (in absolute value) is *model year age*. Firms are much more likely to initiate recalls of current year models, while the government typically initiates older model recalls. In accordance with Claim 3, firms have an incentive to correct safety defects of current year models since many of these vehicles are held as dealer inventory. New-car recalls provide the only opportunity for manufacturers to correct a defective vehicle before it reaches and inconveniences or injures consumers.

Current year model recalls are 27.3 percent less likely to be NHTSA initiated compared to *one & two year old model*. Recalls for *three+ years old model* are 42.6 percent more likely to be NHTSA initiated. These results are due in some degree to the lengthy NHTSA recall process and the lag time in identifying trends in consumer-complaint data. (On average a preliminary NHTSA investigation lasts 140 days. In cases meriting further review the investigation is escalated to an engineering analysis which takes an average of one year to complete.) Nevertheless, there are compelling liability reasons in line with Claim 3 for firms to initiate recalls relatively early in the life of an automobile.

Next, turning to the subset of WSJ recalls (265 of 438), we find some new factors that help explain who initiates a recall. The first advantage of using only newsworthy recalls is the ability to determine how actual hazards (the occurrence of injuries, fires, and accidents) influence the initiation of recalls. Secondly, since many previous recall studies consider only WSJ recalls,[26] we can compare the results for the universe of NHTSA recalls with those that are widely publicized. The WSJ data, however, may suffer from selection bias.[27]

In fact, the bivariate probit model of *initiator* and WSJ-reported recalls

[25] We can, however, reject this hypothesis in the subsample of news-worthy recalls as discussed below.

[26] See Barber and Darrough [1996]; Hoffer, Pruitt, and Reilly [1987], [1988]; and Jarrell and Peltzman [1985].

[27] According to the Assistant Managing Editor, the WSJ publishes recall press releases when they are of interest to its readers, particularly those involving severe safety concerns. See Rupp (2001) for an analysis of *Wall Street Journal* coverage of automotive safety recalls.

reveals that these two seemingly unrelated probit equations do have correlated errors since the estimated $\rho = 0.256$ (z-statistic $= 2.715$) is clearly different from zero.[28] Therefore, the results from the bivariate probit model indicate sample-selection bias for the subset of news-worthy recalls. This result supports using the universe of NHTSA recalls instead of the subset appearing in the WSJ.

Given the above caveat, our primary finding for the widely-publicized recalls is that size plays a reduced role in explaining the recall initiator.[29] This result may be due to the fact that WSJ recalls are nearly twice as large (averaging 345,000 vehicles) than those not publicized (averaging 181,000). For this subset of news-worthy recalls, there is still no significance among firms, and a Wald test that all firm dummies are jointly equal to zero correspondingly cannot be rejected.[30] This result is consistent with that found previously for the universe of recalls.

For the WSJ sample of recalls, we can now reject the one-tailed test of the hypothesis ($H_0 : \beta_{High\ Bond} \geq 0$) that firms having a *high bond rating* are subject to more government-initiated recalls. This finding lends some support to the notion that financially weak firms may require additional policing where initiating recalls is concerned. In particular, the marginal effects indicate that a recall for a high bond rated firm is 25.5 percent less likely to be initiated by the government.

Model year age continues to provide significant explanatory power for the WSJ recalls. The new variables are *accident*, *injury*, and *fire*. *Accident* and *fire* lack explanatory power indicating the superiority of the NHTSA's hazard rating. Interestingly, the government does appear to initiate more *injury* recalls. As Claim 3 suggests, once injuries have occurred, a firm maybe reluctant to initiate a recall since this is an admission to making a defective product which opens the door for liability suits.[31]

To address this liability issue further, we constructed the interaction term *three+ years old model*vehicles recalled*. As hypothesized, for liability reasons the government is significantly more likely to initiate larger recalls of older models since these are the situations in which vehicle owners may have already suffered defect-related injuries (which may or may not have already been reported).

To test the predictive power of the bivariate probit model with regard to the recall initiator, we conduct a one year ahead out-of-sample

[28] See the *Journal*'s editorial Web site for further details about the bivariate probit results for the WSJ estimation which appear in Table AIII of the Appendix (i.e., the probability that the WSJ reports the recall).

[29] These results are not a function of the added variables since similar results are found when these variables are omitted.

[30] The $\chi^2(5) = 8.51$ with a p-value $= 0.1301$.

[31] It is interesting to note that *high hazard* is significantly negative (supporting Claim 1), while *injury* is significantly positive (supporting Claim 3).

predictions from equation (1) using 1980–95 NHTSA data. These sixteen years comprise 72 percent of the sample. We find in 1996 that the model correctly predicts the initiator in 34 of the 42 recalls (81 percent). Likewise the model yields a correct prediction for 26 of the 43 recalls (60 percent) and 38 of the 48 recalls (79 percent) in 1997 and 1998, respectively. In summary, the probit estimation yields a correct prediction of the recall initiator on average 74 percent of the time for these three years.

V. WHICH RECALLS GENERATE THE LARGEST OWNER RESPONSES?

V(i). *Hypotheses*

In this subsection, we present two simple propositions which we then investigate using the NHTSA and WSJ data.

Claim 4: An automobile owner is more likely to respond to a recall if the net change in his expected utility from responding is positive.

While this hypothesis is non-controversial, it is worth pointing out the components that enter into an individual's expected utility calculation when deciding whether to respond to a recall. The personal cost to an auto owner of *not* responding revolves around the future prospect of being injured by the defect and not receiving full compensation from the manufacturer. In the first place, it is often impossible to fully compensate an individual for severe physical injuries (e.g., no amount of money can compensate an individual for his death). In the second place, an individual who fails to respond to a recall notice may have a weak liability case against the manufacturer. Specifically, The auto maker may argue in its defense that the plaintiff's failure to respond to the recall constitutes assumption of the risk, contributory negligence, or comparative negligence.

Next, although manufacturers are required to repair recalled cars free of charge, there still may be significant costs in time and travel from responding to a recall. Hence, the net change in an individual's expected utility from responding to a recall should be decreasing in the requisite time and travel and increasing in the severity of the hazard and probability of injury.

Claim 5: An automobile owner is more likely to respond to a widely publicized recall campaign.

This claim is also straightforward. Clearly, the more likely it is that an auto owner hears about a recall the more apt he is to respond to it.

V(ii). *Estimation*

The dependent variable is *percentage repaired*, and we use the same data sources as in the previous section except that *placard/equipment* recalls are omitted.[32] The explanatory variables are *manufacturer, high hazard, Wall Street Journal, model year age, initiator,* and *inaugural model year*.[33] Manufacturers are classified by nationality where the *U.S. Big Three* represents the domestic auto makers. Manufacturers are also considered individually. Finally, for the subset of news-worthy recalls we also include *accident, injury,* and *fire* as regressors.[34]

The following model is estimated using ordinary least squares (OLS):

$$(4) \qquad Percent\ Repaired = \beta x + \varepsilon$$

where β represents a vector of parameters, x denotes the vector of recall characteristics, and ε is an error term.

A second OLS model for the *percentage repaired* is conditional on appearing in the WSJ. The model is identical to equation (4) with the following exceptions: *accident, injury,* and *fire* are now included in the x vector. All explanatory variables are dummy variables set equal to 0 or 1.

V(iii). *Results*

Table III presents regression estimates and t-statistics based on White [1980] heteroscedasticity-consistent standard errors. The results reveal that vehicle repair rates can be explained by: *U.S. Big Three, high hazard, Wall Street Journal, model year age,* and *inaugural model year*.

First, considering the nationality of the manufacturer, defects for the *U.S. Big Three* are 8.4 percent more likely to be repaired as shown by model 1. A previous study of owner repair rates by Hoffer, Pruitt, and Reilly [1994] finds a similar result and offers the explanation: domestic cars are of lower quality so owners bundle other needed repairs with the recall repair, which lowers the transaction cost of correcting the defect. Guided by Claim 4, we also tell a story based on transaction costs, yet for a different reason. We believe more domestic vehicles are repaired because

[32] Since the NHTSA codes *placard recalls* as 'corrected' if the owner receives the defect notice (i.e., if the manufacturer has a current mailing address), the sample omits *placard recalls* which require no consumer action.

[33] Claims 4 and 5 suggest no reason to include *vehicles recalled* as an explanatory variable. The inclusion of *vehicles recalled* in the model yielded insignificant and slightly negative coefficient estimates.

[34] Accidents, injuries, and fires are coded as 0 if the WSJ does not mention the number of reported occurrences.

TABLE III
PERCENTAGE OF RECALLED VEHICLES REPAIRED, OLS ESTIMATIONS

	Percentage Repaired		*Percentage Repaired conditional on WSJ*	
Variable	Model 1	Model 2	Model 3	Model 4
Constant	0.516	0.600	0.596	0.628
	(15.68)	(16.77)	(14.89)	(17.66)
Ford	–	0.026	–	0.016
		(0.942)		(0.508)
Chrysler	–	−0.009	–	−0.058
		(−0.278)		(−1.384)
Toyota	–	−0.087	–	0.062
		(−2.027)		(0.824)
Honda	–	−0.058	–	−0.086
		(−1.568)		(−1.772)
Nissan	–	−0.084	–	−0.044
		(−1.893)		(−0.874)
U.S. Big Three	0.084	–	0.039	–
	(3.402)		(1.169)	
High hazard	0.056	0.058	0.060	0.063
	(2.706)	(2.765)	(2.186)	(2.303)
Wall Street Journal	0.071	0.062	–	–
	(3.345)	(2.607)		
Current year model	0.030	0.026	0.061	0.072
	(1.027)	(0.888)	(1.706)	(1.985)
Three+ years old model	−0.171	−0.174	−0.132	−0.125
	(−5.027)	(−5.116)	(−3.121)	(−2.986)
Initiator	−0.007	−0.006	0.006	0.009
	(−0.278)	(−0.252)	(0.194)	(0.277)
Inaugural model	0.075	0.078	0.042	0.045
	(2.795)	(2.890)	(1.307)	(1.361)
Accident	–	–	−0.015	−0.014
			(−0.367)	(−0.359)
Injury	–	–	−0.046	−0.042
			(−1.390)	(−1.272)
Fire	–	–	0.117	0.116
			(3.488)	(3.515)
Wald test of firm dummies	–	2.69	–	1.71
(*p-value*)		(0.0208)		(0.1322)
R^2	0.20	0.21	0.18	0.20
Sample size	465	465	283	283

Note: *t*-statistics, in parentheses, are based on White (1980) heteroscedasticity-consistent standard errors. A Wald test of firm dummies tests whether the firm coefficients are jointly equal to zero.

of ubiquitous domestic dealerships which lower the average travel cost of responding to a recall notice.[35]

[35] As of January 1, 1999, GM, Ford, and Chrysler had 8,118, 4,834, and 4,484 U.S. dealerships respectively. Whereas, Toyota/Lexus, Honda/Acura, and Nissan/Infiniti had 1,369, 1,254, and 1,224 U.S. franchises, respectively (*1999 Automotive News Market Data Book*).

Nichols and Fournier [1999] document substantial lower quality for the *U.S. Big Three* during the 1980s. Therefore, if the Hoffer, *et al.*, hypothesis is correct, we should observe a noticeable reduction in repair rates in the 1990s for U.S. cars due to higher quality. With the inclusion of the interaction variable *U.S. Big Three 1990s* (which equals one for Ford, Chrysler, and GM recalls from 1990 to 1998) in model 1, a t-statistic of -0.949 (p-value $= 0.344$) cannot reject the hypothesis that this variable equals zero. Thus repair rates do not appear to have changed substantially for the domestic auto makers between the 1980s and 1990s while quality has improved. The insignificance of the interaction term shows that there is no discernible link between a reduction in needed repairs and the recall response rate.

Results for each individual manufacturer are shown on Table III, model 2. A Wald test that all firm dummies are jointly zero is rejected. All Japanese auto makers have lower repair rates than General Motors with this difference being significant for Toyota.

Supporting Claim 5, widely publicized *Wall Street Journal* recalls generate a 6.2 percent higher rate of owner repairs. This result suggests that the public may benefit from mandatory recall announcements. Since hazardous recalls receive more press coverage,[36] the model controls for this by including: potential hazards (*high hazard*) and for the WSJ sample, actual reported hazards (*accident, injury,* and *fire*) as explanatory variables.

The age of the vehicle recalled, specifically *three+ years old model*, have lower rates of repair. Repair rates for both *current year model* are not statistically different from *one & two year old models*. There are two reasons deriving from Claims 4 and 5 that we would expect owners of older cars to respond less to a recall notice. First, the remaining expected life of an older car is obviously shorter and (other things equal) the probability of being injured by a defect is correspondingly lower. Second, one and two-year-old cars are very likely to be under service warranty. Hence, borrowing from the Hoffer, Pruitt, and Reilly [1994] story, owners of new cars are likely to bundle recall repairs with service warrantee work and other regularly scheduled maintenance trips to the dealer.

Finally, *inaugural model year* vehicles have significantly higher repair rates. Owners of these introductory models appear sensitive to vehicle imperfections. This is not surprising, since introductory models are widely known to have more design and manufacturing defects. Hence, we would expect the buyers of inaugural models to be those individuals for whom the cost of responding to recalls is relatively low.

[36] WSJ published recalls are also slightly more hazardous as 43 percent of the newsworthy sample have *high hazard* defects compared to 40 percent for the universe of recalls.

The final noteworthy finding is the fact that the recall initiator has no significant affect on owner response rates. In fact, it is highly unlikely that owners would know whether NHTSA or the manufacturer had initiated a given recall. It is, however, comforting to observe that the recall initiator does not proxy for some other characteristic that owners do observe and care about.[37] In other words, it would be difficult to justify a significant difference in response rates due to the recall initiator in the context of Claims 4 and 5.

Next, consider the subset of newsworthy or widely publicized WSJ recalls. Most of the findings for the universe of recalls also hold for this subset. For instance, *high hazard* and *three+ years old model* continue to have significant explanatory power.

Curiously, models 3 and 4 show the nationality of the manufacturer loses significance in explaining owner response rates when going from the universe of recalls to the WSJ subset. Moreover, a Wald test that all firm dummies are jointly equal to zero can no longer be rejected. This result may be due in part to the fact that the WSJ subsample contains a somewhat lower percentage of recalls by Japanese auto makers (16.5%) as compared with the universe of recalls (21.3%). Also, as noted above, the WSJ tends to report a slightly higher percentage of *high hazard* recalls to which both domestic and foreign car owners are more likely to respond.

For the additional explanatory variables representing actual hazard experiences: *accident, injury*, and *fire*, we find owners are approximately 12 percent more likely to repair vehicles with known fire hazards. *Accident* and *injury*, on the other hand, provide surprisingly little indication of repair rates. This result may be because the manufacturer prepared press release typically contain little information on the extent of injuries suffered by consumers while emphasizing the existence of minor injuries. For example, when Chrysler recalled 740,000 1995–97 model year Cirrus, Stratus, Breeze, and Sebring vehicles due to corrosion in the front suspension: 'The auto maker said it had received about 27 reports of the condition, including two accidents that resulted in one minor injury' (*Wall Street Journal*, December 22, 1997). In this case, owners might infer that the probability of suffering a minor injury is 1 in 740,000, which could actually discourage them from repairing a defective vehicle.

For the universe of NHTSA recalls, owners typically repair newsworthy hazardous defects of current year domestic vehicles in their inaugural model year. Assigning a zero weight to the *initiator* variable, the model predicts 83.2 percent of all vehicles recalled with the above characteristics will be repaired within six quarters, whereas, a recall with the exact

[37] For instance, if *high hazard* is dropped from the regression (a clear misspecification), then *initiator* becomes significantly negative because recalls involving highly hazardous defects are usually initiated by the manufacturer.

opposite attributes has a predicted repair percentage of 34.5. The actual data for these recalls were 85.2 and 37.5 percent, both samples included 12 observations.

VI. CONCLUSION

In this paper we use nineteen years of NHTSA data involving the six largest manufacturers to investigate two questions. First we explore which entity (the government or the manufacturer) is most likely to initiate a given recall campaign. Second, we analyze the determinants of recall response rates by car owners.

We find that the government is more likely to initiate larger, less hazardous recalls involving older models, financially weak firms, and reported injuries. Firms conduct recalls when the benefits (reduced expected liability) exceed the expected cost of repairs. Inexpensive recalls in the form of a placard mailing are more likely to be manufacturer-initiated. Concerning the determinants of recall response rates, we provide new evidence that owners are more likely to repair domestic vehicles with hazardous defects. We also find higher repair rates for new vehicles and inaugural year models

Manufacturers sometimes miscalculate the expected costs and benefits of conducting a recall. The Malibu court case cited in the Introduction affords an excellent example of this. GM did not recall the vehicle and redesign the fuel system 'because the additional cost of $8.59 a car was greater than paying [estimated] claims for fuel-fire deaths' (*Wall Street Journal*, 12 July 1999). An internal memo written by a GM engineer in 1973 estimated that each fuel-related death would cost the company $200,000 or $2.40 per vehicle currently on U.S. roads. Viscusi [1993] reports that most value-of-life estimates are in the $3 million to $7 million range (or $900 thousand to $2.1 million deflated to 1973). The trial judge has since reduced the jury award to $1.09 billion, however, GM is still appealing for a further reduction of the award (*Wall Street Journal*, August 27, 1999). Nevertheless, GM appears to have badly underestimated the economic value of a human life in this case.[38]

Why didn't NHTSA initiate a Malibu recall? Our findings suggest that the safety agency focuses on marginal defects, leaving the manufacturers to deal with the obvious ones. Given limited budgetary resources, this is a rational strategy for the NHTSA to employ. Moreover, in a world of perfect information—where cost and benefit estimates are always

[38] Even at the lower bound of $900,000 for the value of a human life in 1973 dollars, the expected liability cost per vehicle is $10.80 which is more than four times GM's estimate. It is, of course, possible (even probable) that the value of human life has increased relatively since 1973, but almost certainly not enough to justify GM's failure to recall the Malibu.

accurate—the strategy of leaving the 'obvious' recalls for manufacturers to initiate would work flawlessly. Unfortunately, it appears that GM made a serious forecast error in this case, and even if NHTSA became aware of this error, it may have been to late to do anything about it.[39]

What policy implications do our findings support? Since recalls appearing in the WSJ are more likely to be repaired, we suggest that the NHTSA reconsider its policy (adopted in 1981) of not issuing press releases for safety recalls. Secondly, the safety agency could modify its recall notification letter to include its hazard rating of the defect and whether it has resulted in known injuries. Another inexpensive way of potentially raising correction rates would be to require manufacturers to send a second recall notice to the owners of foreign makes and/or vehicles three or more years old. Currently manufacturers have the option to send a second notice. Since the NHTSA relies solely on consumer complaints to initiate recalls, any policy that encourages consumers to report safety defects seems wise. We support the recent NHTSA advertising campaign (i.e., billboards, buses, and airport posters promoting the agency's safety complaint hot-line) as an effective way to increase consumer awareness of the importance of reporting defects. Additionally, allowing consumers to file safety defect complaints via the Internet has also reduced the time necessary to file a report. Finally, since automobiles now last considerably longer than they did in 1966, raising the eight-year limit for recalls might well be justified.

[39] Currently, manufacturers are not legally bound to recall cars more than eight years old. Defects involving a small probability of a catastrophic outcome may take a long time to identify. For instance, the Malibu at the heart of the California court case was fourteen years old when its fuel tank ruptured in a collision.

APPENDIX

TABLE AI
NATIONALITY OF THE MANUFACTURER IN THE BIVARIATE PROBIT

Variable	*Pr(Initiator)*	*Pr(WSJ Reported)*
Constant	−0.269	−0.655
	(−0.917)	(−2.532)
U.S. Big Three	−0.016	0.310
	(−0.076)	(1.799)
Ford*Vehicles recalled	0.153	0.090
	(2.864)	(1.645)
Chrysler*Vehicles recalled	0.222	0.036
	(2.767)	(0.681)
GM*Vehicles recalled	0.009	0.050
	(0.460)	(1.086)
Toyota*Vehicles recalled	0.722	−0.195
	(2.856)	(−0.989)
Honda*Vehicles recalled	−0.039	0.140
	(−0.672)	(1.609)
Nissan*Vehicles recalled	−0.005	0.078
	(−0.055)	(1.134)
High hazard	−0.443	0.087
	(−2.153)	(0.710)
Percent repaired	0.104	0.777
	(0.350)	(2.902)
Placard/Equipment recall	−0.745	–
	(−1.911)	
High bond rating	−0.443	0.051
	(−1.716)	(0.254)
Current year model	−0.928	−0.022
	(−4.597)	(−0.119)
Three+ years old model	1.107	−0.089
	(4.491)	(−0.372)
Three+ years*Vehicles recalled	0.055	0.001
	(0.957)	(0.014)
Inaugural model	0.367	0.260
	(1.865)	(1.321)
Log likelihood	−518.75	
Sample size	479	479

Note: *z*-statistics, in parentheses, are based on White (1980) heteroscedasticity-consistent standard errors. *Placard/Equipment recall* is omitted from the *WSJ* estimation due to a lack of *WSJ* observations.

TABLE AII
TESTING FOR NONLINEARITIES IN THE BIVARIATE PROBIT ($n = 479$)

Variable	*Pr(Initiator)*	*Pr(WSJ Reported)*
Constant	−0.770	−0.218
	(−2.394)	(−0.831)
Ford	0.515	0.479
	(1.561)	(2.347)
Chrysler	0.643	−1.237
	(1.862)	(−5.080)
Toyota	0.765	−1.441
	(1.157)	(−3.995)
Honda	0.459	−0.301
	(0.945)	(−0.875)
Nissan	0.964	−0.164
	(2.235)	(−0.650)
Ford*Vehicles recalled	0.126	0.000
	(0.889)	(0.009)
Chrysler*Vehicles recalled	0.152	0.269
	(0.705)	(3.548)
GM*Vehicles recalled	0.214	0.026
	(2.804)	(0.876)
Toyota*Vehicles recalled	−2.000	0.059
	(−1.126)	(0.927)
Honda*Vehicles recalled	−0.576	0.108
	(−1.286)	(1.265)
Nissan*Vehicles recalled	−0.228	0.037
	(−0.539)	(0.803)
Ford*(Vehicles recalled)^2	0.005	–
	(0.372)	
Chrysler*(Vehicles recalled)^2	0.004	–
	(0.162)	
GM*(Vehicles recalled)^2	−0.007	–
	(−1.730)	
Toyota*(Vehicles recalled)^2	1.835	–
	(1.590)	
Honda*(Vehicles recalled)^2	0.061	–
	(1.318)	
Nissan*(Vehicles recalled)^2	0.019	–
	(0.312)	
High hazard	−0.298	0.165
	(−2.082)	(1.271)
Percent repaired	0.092	0.805
	(0.303)	(2.800)
Placard/Equipment recall	−0.661	–
	(−1.755)	
High bond rating	−0.213	0.250
	(−0.746)	(0.988)
Current year model	−0.957	−0.058
	(−4.483)	(−0.308)
Three+ years old model	1.177	−0.194
	(3.878)	(−0.871)
Three+ years*Vehicles recalled	0.020	0.015
	(0.167)	(0.533)
Inaugural model	0.319	0.481
	(1.593)	(2.152)
Log likelihood	−474.87	

Note: z-statistics, in parentheses, are based on White (1980) heteroscedasticity-consistent standard errors. *Placard/Equipment recall* is omitted from the *WSJ* estimation due to a lack of *WSJ* observations.

TABLE AIII
PROBABILITY THAT THE *WSJ* REPORTS THE RECALL

Model Sample	Bivariate Probit All	
Variable	Coefficient	Marginal Effect
Constant	−0.209 (−0.807)	–
Ford	0.472 (2.336)	0.145
Chrysler	−1.244 (−5.164)	−0.451
Toyota	−1.446 (−4.012)	−0.484
Honda	−0.310 (−0.905)	−0.078
Nissan	−0.171 (−0.684)	−0.070
Ford*Vehicles recalled	−0.001 (−0.027)	−0.001
Chrysler*Vehicles recalled	0.269 (3.532)	0.092
GM*Vehicles recalled	0.022 (0.927)	0.006
Toyota*Vehicles recalled	0.059 (0.358)	0.016
Honda*Vehicles recalled	0.109 (1.241)	0.016
Nissan*Vehicles recalled	0.037 (0.772)	0.012
High hazard	0.165 (1.268)	0.055
Percent repaired	0.804 (2.798)	0.271
High bond rating	0.245 (0.969)	0.066
Current year model	−0.059 (−0.316)	−0.017
Three+ years old model	−0.196 (−0.882)	−0.053
Three+ years*Vehicles recalled	0.016 (0.624)	0.004
Inaugural model	0.482 (2.152)	0.153
Log likelihood	−480.21	
Sample size	479	

Note: z-statistics, in parentheses, are based on White (1980) heteroscedasticity-consistent standard errors. See Table 2 for the bivariate probit results for the probability of initiator recalls.

REFERENCES

Automotive News Market Data Book 1999, Detroit, MI.

Barber, B. M. and Darrough, M. N., 1996, 'Product Reliability and Firm Value: The Experience of American and Japanese Automakers, 1973–1992', *Journal of Political Economy*, 104(5), pp. 1084–1099.

Bromiley, P. and Marcus, A., 1989, 'The Deterrent to Dubious Corporate Behavior: Profitability, Probability and Safety Recalls', *Strategic Management Journal*, 10(3), pp. 233–250.

Casella, G. and Berger, R. L., 1990, *Statistical Inference* (Duxbury Press, Belmont, California).

Chatterjee, S. and Price, B., 1991, *Regression Analysis by Example*, 2nd edn. (John Wiley and Sons, New York).

Crafton, S. M., Hoffer, G. E. and Reilly, R. J., 1981, 'Testing the Impact of Recalls on the Demand for Automobiles', *Economic Inquiry* 19(4), pp. 694–703.

Daughety, A. F. and Reinganum, J. F., 1995, 'Product Safety: Liability, R&D, and Signaling', *American Economic Review*, 85(5), pp. 1187–1206.

Davidson, W. N. III and Worrell, D. L., 1992, 'Research Notes and Communications: The Effect of Product Recall Announcements on Shareholder Wealth', *Strategic Management Journal*, 3(6), pp. 467–473.

GAO Report, B-223735, 1989, 'Motor Vehicle Safety Passive Restraints Needed to Make Light Trucks Safer', GAO/RCED-90-56, U.S. GAO.

Garber, S. and Adams, J., 1998, 'Product and Stock Market Responses to Automotive Product Liability Verdicts', *Brookings Papers on Economic Activity: Microeconomics 1998* (Brookings Institution: Washington).

Garber, S. and Bower, A. G., 1999, 'Newspaper Coverage of Automotive Product Liability Verdicts', *Law & Society Review*, 33(1), pp. 93–122.

Greene, W. H., 2000, *Econometric Analysis* (Prentice-Hall: Upper Saddle River, New Jersey).

Hartman, R. S., 1987, 'Product Quality and Market Efficiency: The Effect of Product Recalls on Resale Prices and Firm Valuation', *The Review of Economics and Statistics*, 69(2), pp. 367–372.

Hoffer, G. E., Pruitt, S. W. and Reilly, R. J., 1987, 'Automotive Recalls and Informational Efficiency', *The Financial Review*, 22(4), pp. 433–442.

Hoffer, G. E., Pruitt, S. W. and Reilly, R. J., 1988, 'The Impact of Product Recalls on the Wealth of Sellers: A Reexamination', *Journal of Political Economy*, 96(3), pp. 663–670.

Hoffer, G. E., Pruitt, S. W. and Reilly, R. J., 1994, 'When Recalls Matter: Factors Affecting Owner Response to Automotive Recalls', *Journal of Consumer Affairs*, 28(1), pp. 96–106.

Huber, P. W. and Litan, R. E., 1991, *The Liability Maze: The Impact of Liability Law on Safety and Innovation* (Brookings Institution: Washington).

Hunziker, J. R. and Jones, T. O., 1994, *Product Liability and Innovation: Managing Risk in an Uncertain Environment, National Academy of Engineering* (National Academy Press: Washington).

Jarrell, G. and Peltzman, S., 1985, 'The Impact of Product Recalls on the Wealth of Sellers', *Journal of Political Economy*, 93(3), pp. 512–536.

Marino, A. M., 1997, 'A Model of Product Recalls with Asymmetric Information', *Journal of Regulatory Economics*, 12(3), pp. 245–265.

McCarthy, P. S., 1990, 'Consumer Demand for Vehicle Safety: An Empirical Analysis', *Economic Inquiry*, 27(3), pp. 530–543.

Moody's Bond Record [1980–1998], (Moody's Investor Services, New York).

'National Traffic and Motor Vehicle Safety Act of 1966', *US Code Congressional & Administrative News*, 1, 1381 (US Government Printing Office, Washington).
Nichols, M. W. and Fournier, G. M., 1999, 'Recovering from a Bad Reputation: Changing Beliefs About the Quality of U.S. Autos', *International Journal of Industrial Organization*, 17(3), pp. 299–318.
Reilly, R. J. and Hoffer, G. E., 1983, 'Will Retarding the Information Flow on Automobile Recalls Affect Consumer Demand?', *Economic Inquiry*, 21(3), pp. 444–447.
Rupp, N. G., 2001, 'Are Government Initiated Recalls More Damaging for Shareholders? Evidence from Automotive Recalls, 1973–1978', *Economics Letters*, 71(2), pp. 265–270.
Rupp, N. G., 2001, 'What Constitutes a Newsworthy Recall?', working paper, (East Carolina University, Greenville, NC).
United States Court of Appeals, Eighth Circuit 1968: *Larsen vs. General Motors*. 391 Federal 2nd at 502.
Uri, N. D., 1989. 'A Reconsideration of the Impact of Recalls on the Market Valuation of a Product', *Economic Modelling*, 6(4), pp. 457–466.
Viscusi, W. K., 1993, 'The Value of Risks to Life and Health', *Journal of Economic Literature*, 31(4), pp. 1912–1946.
Wall Street Journal Index [1980–1998], New York, Dow-Jones.
Wall Street Journal. 1996, 'Chrysler Is Sued by U.S. to Force Recall of Cars'. 5 June, p. B1.
Wall Street Journal. 1997, 'Chrysler is Recalling 1.3 Million Sedans and Pickup Trucks'. 22 December, p. B10.
Wall Street Journal. 1998, 'U.S. Court Overturns NHTSA Recall Order of Chrysler Vehicles'. 2 November, p. A25.
Wall Street Journal. 1999, 'GM Ordered by Jury to Pay $4.9 Billion'. 12 July, p. A3.
Wall Street Journal. 1999, 'GM Verdict Cut $3.8 Billion in Suit Over Explosion'. 27 August, p. B5.
Ward's Automotive Yearbook 1998, Detroit, MI.
Welling, L., 1991, 'A Theory of Voluntary Recalls and Product Liability', *Southern Economic Journal*, 57(4), pp. 1092–1111.
White, H., 1980, 'A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity', *Econometrica*, 48:4, pp. 817–838.