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THE ATTRIBUTES OF A COSTLY RECALL: EVIDENCE FROM THE AUTOMOTIVE INDUSTRY

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The Attributes of a Costly Recall: Evidence from the Automotive Industry

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Abstract. While researchers have extensively documented the equity response to product recalls and subsequent shareholder losses, less attention in the literature has been given to examining the damaging recall attributes. Using 1973–1998 automotive safety recall data, this study identifies the kinds of recalls that cause significant shareholder losses. After constructing an equally-weighted automotive market index to control for industry effects and adjusting the abnormal returns to account for the degree of surprise in the recall announcement, the study estimates both percentage and real dollar abnormal returns. We find that the indirect costs of automotive recalls are likely larger than the direct costs.

Key words: abnormal returns, automobile defects, NHTSA, recall attributes.

I. Introduction

Product recalls have been extensively examined in the literature with researchers finding that such actions are typically damaging for shareholder value.[1] While the equity response to product recalls has attracted considerable attention, the recall attributes that cause these significant shareholder losses has received little attention. For example, Barber and Darrough (1996) examine the market reaction over different time periods and whether this reaction differs between Japanese and American companies. Hoffer et al. (1987) estimate the abnormal returns of severe safety recalls. Jarrell and Peltzman (1985) consider only large automotive safety recalls appearing in the *Wall Street Journal* (WSJ). Rupp (2001) compares the equity responses of government-initiated and firm-initiated automotive recalls. Recall attributes are potentially important given that Hoffer et al. (1994) find vehicle age, defect severity, and nationality of manufacturer all

[1] Jarrell and Peltzman (1985), Hoffer et al. (1987) and Barber and Darrough (1996) all find significant shareholder losses surrounding automotive recall announcements. Likewise, Pruitt and Peterson (1986) and Davidson and Worrell (1992) have similar findings for non-automotive recalls. Not every study reaches the same conclusion, since Hoffer et al. (1988) revisit the Jarrell and Peltzman (1985) data and find insignificant shareholder returns.

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affect the owner response rate to have the recalled vehicle repaired. A novelty of this paper is the grouping of recalled components into one of 12 categories, ranging from air bags to frame and bumpers, to determine which defective components are especially costly for manufacturers. The purpose of this study is to identify the recall attributes that cause significant shareholder losses.

This paper considers automotive safety recalls between 1973 and 1998 for the six largest producers of cars and trucks in the United States: Chrysler, Ford, GM, Honda, Nissan, and Toyota. Jointly these six automakers held a combined 1997 U.S. market share of 90% (*Ward's Automotive yearbook* 1998). Similar to prior work, this paper examines equity responses of automotive recalls appearing in the WSJ. Unlike prior studies, however, this paper constructs an automotive market index and uses it to calculate abnormal returns by comparing the automotive company to the automotive index. Such a specification enables a separation of industry effects from individual firm effects. For example, an automotive index would capture effects of an OPEC announcement or a Federal Reserve announcement which may change gasoline prices or interest rates, respectively. Both of these events would likely also effect auto sales and hence equity valuations of auto manufacturers.

Another notable difference between this paper and prior work is that this study accounts for the fact that investors commonly have information about recalls prior to WSJ announcements. Specifically, the abnormal returns are adjusted by the degree of surprise in the WSJ announcement. Government-initiated recall campaigns typically involve multiple investigation stages. By using historical recall rates conditional on a given investigation stage, we are able to adjust the abnormal returns to reflect an investor's recall expectations.

Some defective components are more costly (*air bags*), whereas others (*heaters, defrosters & A/C*) are significantly less costly. The estimations also control for other recall characteristics (i.e., model year age, number of vehicles, and recall history). The results indicate that recalls involving the *initial recall* of a model, make are significantly more expensive for auto manufacturers. There is some evidence that recalls of *two+ model-year old* vehicles are also more costly. Finally, the estimations include company characteristics (*market capitalization*, financial stability, and nationality of manufacturer). Of these, firms with the highest financial stability (*AAA bond-rating*) experience the greatest shareholder losses from automotive safety recalls. The next section reviews the recall announcement process and recall expectations. This is followed by a discussion of the data and the constructed automotive index. The final two sections include empirical results and concluding remarks.

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II. The Recall Announcement Process

Since it was founded in 1966, the National Highway and Traffic Safety Administration (NHTSA) has been responsible for tracking car and truck safety recalls. Almost all recalls are considered voluntary; in only nine cases since 1966 has the NHTSA taken a manufacturer to court to force a recall.[2] To initiate a voluntary recall, the manufacturer sends a notification memo to the NHTSA detailing the forthcoming recall campaign. Manufacturers are required to notify the NHTSA when a vehicle or equipment fails to meet existing safety standards. Copies of these memos are publicly posted on the same day or at the latest on the following day and are available only in the Department of Transportation's Technical Reference Library (Room 5108) in Washington, DC.[3] According to the Assistant Managing Editor of the WSJ, the primary source of recall stories comes from manufacturer-issued press releases.[4] Manufacturers also tend to bunch recall announcements, which enables them to draft on another firm's announcement. Manufacturers may also opt to delay issuing a press release until after their dealerships are adequately stocked with the replacement part(s). Manufacturers that choose not to issue recall-related press releases do not avoid media detection since the NHTSA publishes a monthly summary of recall campaigns and on-going defect investigations since 1981.[5] Prior to 1981, the NHTSA publicly announced every safety-related recall campaign (Reilly and Hoffer, 1983).

Since Hoffer et al. (1987) previously found no significant market reaction to the NHTSA filing date and significant negative abnormal returns to the WSJ announcement; hence this analysis focuses on WSJ recall announcements. Nonetheless, we are able to examine the possibility of information leakage by including an *announcement lag* variable which counts the number of days between the NHTSA filing date and the WSJ announcement date. If both events happen on the same day, then *announcement lag* = 0 otherwise, this variable is a positive integer. The average and median lag between filing date and announcement date is 33 and 24 days, respectively.

1. PROBABILITY OF GOVERNMENT-INITIATED RECALLS

Recalls are classified as either manufacturer or government-initiated. Specifically, recalls are considered manufacturer-initiated if the NHTSA had not

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[2] A recent such case occurred on June 4, 1996 when the NHTSA ordered Chrysler to recall 91,000 1995 Chrysler Cirrus and Dodge Stratus models. A Federal Appellate court sided in favor of Chrysler and overturned the recall order (*Wall Street Journal*, November 2, 1998).

[3] Surprisingly, the NHTSA has not taken advantage of technological improvements to make notification memos and recall announcements available electronically on the Internet.

[4] Per a phone interview conducted by the author with the Assistant Managing Editor of the WSJ.

[5] Since 1996 the NHTSA recall summary report has appeared on its web site: www.nhtsa.dot.gov.

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opened a defect safety investigation prior to the company's decision to conduct a recall.[6] Government-initiated recalls follow a series of investigative stages, at any point during this investigation process the manufacturer can opt to conduct a recall, in which case the NHTSA would halt its safety investigation. The NHTSA collects data from written, telephone, or electronic submission of consumer complaints. Every complaint is forwarded to the manufacturer. If the NHTSA receives enough common complaints about a particular defective component, then the government safety agency may opt to open a preliminary investigation into the defective component. The NHTSA also contacts the manufacturer to inform them that a formal investigation has begun of a potentially defective component. The NHTSA database includes a listing of every preliminary investigation and the ultimate result of the investigation. Between 1985 and 1998, the NHTSA conducted 1305 preliminary investigations involving automotive safety issues.[7] Of the 1305 preliminary investigations only 223 (or 17%) resulted in a recall. Hence, the expected probability of a recall given a preliminary investigation just prior to the WSJ announcement is 0.17.

After conducting a preliminary investigation, the recall investigation can follow one of three courses. The most common outcome is that the safety agency drops its investigation.[8] One in ten preliminary investigations results in a recall before the preliminary investigation has been completed. Finally, in approximately one-third of the cases, the NHTSA chooses to escalate its preliminary investigation to an "engineering analysis" stage. Both the preliminary investigations and engineering analysis stages appear in a monthly NHTSA summary/status report.

The engineering analysis stage involves vehicle testing by the NHTSA. The safety agency attempts to determine whether the vehicle complies with existing federal safety standards. Once again, the manufacturer can opt to recall the vehicle at any time, in which case the NHTSA would halt its testing. Otherwise, the engineering analysis case is completed by the NHTSA, which shares its findings with the manufacturer. If the test results reveal that the component meets existing safety standards, then no recall is needed. In situations, however, where the defective component does not comply with the safety standard, then the manufacturer is asked to conduct a safety recall. The testing procedures and the interpretation of the test results are

[6] For more details on which party (manufacturer or government) initates a recall, see Rupp and Taylor (2002).

[7] Prior to 1985, the NHTSA did not conduct preliminary investigations. Instead, the NHTSA opened cases which occurred only after the manufacturer refused to voluntarily conduct a recall.

[8] For the six sample manufacturers between 1985 and 1998, the outcomes from preliminary investigations were: closed (51.6%), escalated to engineering analysis (37.9%), or recalled (10.5%).

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commonly sources of contention between the manufacturer and the safety agency. For example, Chrylser accused the NHTSA of using a "flawed crash test" which was specifically designed to make the rear door latch of the Chrysler minivan spring open (*Wall Street Journal*, 1 February 1995b).[9] The NHTSA has opened a total of 1633 engineering analysis cases between 1972 and 1998. Just 318 (or 20%) of these cases resulted in a recall. Hence, the expected probability of a recall given an engineering analysis case just prior to the WSJ announcement is 0.20.

III. Data

1. RECALL SAMPLE

Data for safety recall announcements[10] for cars and trucks in the United States are collected from the *WSJ Index* for the six largest auto manufacturers in the United States.[11] These announcements are then matched to the corresponding NHTSA safety recall campaign. This safety agency lists every U.S. motor vehicle recall since 1966 and contains information not typically provided by the WSJ, including: (i) initiator of the recall; (ii) defective component listing; (iii) the number of defective vehicles repaired six quarters following the announcement; (iv) the stage of the NHTSA defect investigation prior to the recall announcement; and (v), NHTSA recall filing date. The NHTSA data are obtained from the safety agency's web site.[12]

Due to the increasing presence of Japanese automakers in the U.S. market,[13] this study includes both domestic (Chrysler, Ford, and General Motors) and *Japanese manufacturers* (Honda, Nissan, and Toyota).[14] The beginning of the sample in 1973 corresponds to the first complete year that stock returns for the Japanese automakers in the form of American Depository Receipts (ADRs) are available. Since many smaller foreign automakers

[9] In late-January 1995, the NHTSA had privately urged Chrysler to voluntarily recall the four million minivans and replace the rear-door latch citing 25 latch-related deaths (*Wall Street Journal*, 27 January 1995a). In March 1995, Chrysler agreed to replace all 4.5 million latches on its minivans in a "service action" not a recall campaign, which would be an admission of manufacturing a defective component (*Wall Street Journal*, 28 March 1995b).

[10] Auto manufacturers also conduct environmental recalls (regulated by the EPA), which are excluded from the sample.

[11] I thank Brad Barber and Masako Darrough for making their 1973–92 WSJ recall data available.

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

[13] In 1997, Honda, Nissan, and Toyota held 19.1% U.S. market share for cars and light trucks (*Ward's Automotive Yearbook 1998*).

[14] Daimler-Chrysler began trading on November 17, 1998. There were no Chrysler safety recalls in the sample after this date, however.

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Table I. Descriptive statistics for Wall Street Journal vehicle safety recall announcements 1973–1998 ($n = 592$)

Variable	Mean	Std. dev.	Min	Max
Dependent variables				
Adjusted percentage CAR	−0.077	1.194	−5.354	4.675
Adjusted real dollar CAR (in millions)[a]	−9.470	219.836	−1841.82	1251.21
Defective components				
Air bag	0.020	0.141	0	1
Brakes	0.154	0.361	0	1
Electrical	0.046	0.209	0	1
Engine	0.139	0.346	0	1
Equipment (speed control, jacks, radio, etc.)	0.030	0.172	0	1
Frame & Bumpers	0.020	0.141	0	1
Fuel & Exhaust	0.188	0.391	0	1
Heater, Defroster & A/C	0.015	0.122	0	1
Latches & Locks	0.037	0.189	0	1
Seats & Seat belts	0.100	0.300	0	1
Steering, Suspension & Wheels	0.199	0.400	0	1
Visual systems	0.052	0.223	0	1
Recall characteristics				
Current model year	0.545	0.438	0	1
One-model-year old	0.184	0.281	0	1
Two^{+} model-year old	0.272	0.394	0	1
Initial recall of make/model/year	0.486	0.480	0	1
ln vehicles repaired	10.159	2.123	3.66	15.33
Percent repaired	0.649	0.225	0.02	1.0
ln vehicles recalled	10.688	2.119	3.66	15.88
Preliminary investigation	0.315	0.453	0	1
Engineering analysis	0.170	0.367	0	1
Government-initiated	0.338	0.473	0	1
Announcement lag (days)	32.84	38.71	0	384
Company characteristics				
ln market capitalization (in millions)	9.361	1.109	5.68	11.59
AAA bond rating	0.372	0.484	0	1
Japanese manufacturer	0.113	0.317	0	1

[a] *Note*: Real dollars use August, 1983 as the basis.

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are not listed on the U.S. security exchanges, the sample is limited to the six largest manufacturers of cars and light trucks in the United States.

During the twenty-six year sample period from 1973 to 1998, the *WSJ* published 592 safety recalls involving approximately 138 million vehicles for the six manufacturers (see Table I). The largest yearly recall total in history occurred in 1995, when more vehicles were recalled (15.3 million) in the U.S. than were sold (15.2 million).[15] Automobile manufacturers are required to conduct a recall due to safety-related defects for vehicles up to eight years old. The recalls vary in size from 39 Buick Reattas with defective air bag sensors to 7.9 million 1989 – 1993 Ford Motor Company vehicles with faulty ignition switches. We use the natural logarithm of *vehicles recalled* to smooth the large variability in the total number of units recalled.

All recall characteristics are obtained from the NHTSA. We group vehicles into one of three age categories: *current model year, one model-year old,* and *two+ model-year old* vehicles.[16] Model year age presents opposing effects on recall costs. First, the direct costs rise for newer model vehicle recalls since previous research by Rupp and Taylor (2002) and Hoffer et al. (1994) have shown that owners are more likely to repair newer vehicles. Second, the indirect costs rise for older model vehicles since these recalls pose a greater liability issue for manufacturers due to a higher likelihood that defect-related passenger injuries have already occurred. *Current model year* vehicles comprise a little over half of the sample and a portion of which are still likely to be held as unsold dealership stock. Since some of these recalled vehicles have not yet reached consumers, there is a smaller probability that a consumer has been harmed by this defect. Hence, these recalls pose less liability for the manufacturers. On the other hand, recalls of vehicles in the *two+ model-year old* category pose greater liability issues for the manufacturer since consumers have had longer exposure to the defect and hence a significant number of injuries may have already occurred (which may or may not have been previously reported to the manufacturer). While a recall is not an admission of negligence by the manufacturer, it is recognition of a product defect. To determine if a vehicle's recall history (or lack of history) affects the equity response, estimations include *initial recall* which equals one if this is the first time that a recall for this make, model, and year has been reported by the WSJ.

[15] The 15.3 million recalled vehicles span thirteen model years (between 1984 and 1996), whereas the 15.2 million only reflects vehicle sales in the 1995 calendar year. In addition, more than half of all vehicles recalled in 1995 were due to one seat belt recall by Tanka, Inc. (Japan), which involved 7.9 million U.S. vehicles.

[16] The NHTSA data do not provide model year breakdowns for multi-model year recalls (i.e., the NHTSA may announce that 30,000 1989–1991 Ford Escorts are being recalled). Hence, if this announcement occurred in calendar year 1991, we assign *current model year* = 0.333, *one-model year old* = 0.333, and *two+ model year old* = 0.333.

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Since the NHTSA also reports the number of defective *vehicles repaired* six quarters following the recall announcement, we construct *percent repaired* by dividing the number of *vehicles repaired* by the number of *vehicles recalled*. Of course, at the time of the WSJ recall announcement *percent repaired* is unknown. If we assume, however, that investor expectations of *percent repaired* is on-average correct, then the actual and expected repair rate will be equivalent. Once again, we use the natural logarithm to smooth the number of *vehicles repaired*.

In every safety recall the NHTSA lists the defective component. We group these components into one of sixteen categories. Component categories provide a crude proxy for the direct costs of conducting a recall. For example, *engine* recalls are likely to be more costly than *seat belts*, all else equal. In addition, the component category might provide insight into the potential defect liability. For example, defects involving faulty *brakes* might be more hazardous than faulty *heaters, defrosters & A/C*.

This paper makes no allowance for whether automotive manufacturers share some recall related costs with their suppliers, particularly in the case of air bag recalls.[17] So clearly, the automotive companies may not bear the entire recall related costs in certain instances. Rather than reducing the abnormal returns by an arbitrary percentage due to cost sharing, we use the abnormal returns determined by the equity market under the assumption that investors are fully informed as to what extent, if any, cost-sharing is occurring. For example, consider the extreme case where TRW reimburses Ford for all direct costs associated with a faulty TRW airbag. In this case, Ford shares should be unaffected by the recall announcement, even if investors are fully informed of this arrangement. Ford may still, however, suffer some shareholder losses due to a reduction in goodwill or a tarnishing of its high-quality reputation. Hence, even if cost-sharing situations exist, we make no adjustments to the market determined abnormal returns.

Finally, data on stock prices and shares outstanding come from the Center for Research in Security Prices (CRSP) at the University of Chicago. *Market capitalization* is the stock price multiplied by the number of shares outstanding. We use *Moody's Bond Record* for corporate bond ratings for each automotive company. The dummy variable *AAA bond rating* equals one for the companies with best quality bond ratings of AAA-, AAA, or AAA+ at the time of the WSJ recall announcement.[18] Slightly more than one-third

[17] For example, following recalls of TRW air bags by GM, Ford, and Honda, TRW's chairman Joseph T. Gorman reported that his company "would take a 'modest' one-time charge in the 4th quarter (due to) recalls and other recent problems with air-bag deployment" (*Wall Street Journal*, 3 January 1991).

[18] Most companies have the identical bond rating regardless of the length until maturity. In cases where these differ, we use the bond rating for the note with the earliest maturity date.

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of the sample involves automotive companies with *AAA bond ratings*. Bond ratings are not available in the early 1980s for the Japanese auto makers because these firms did not issue corporate bonds until the mid-1980s. To prevent a loss in observations, we use debt-to-equity ratios to forecast bond ratings during this period for the Japanese automakers. The next section presents the details for the automotive index used to determine the equity impact of the WSJ safety recall announcements.

IV. Automotive Index

To estimate the financial impact of recalls, abnormal returns are calculated from CRSP stock price data for each recall announcement (Brown and Warner, 1985; MacKinlay, 1997). To minimize the influence of other events on the equity response to recalls, we use a 2-day window, which includes the day before and the day of the WSJ recall announcement. The returns data include the stock prices of the domestic auto manufacturers and ADR prices for the Japanese companies. All returns are in U.S. dollars.

We construct an equally-weighted automotive market index to control for industry effects. The composition of this industry portfolio varies from firm to firm. For example, if GM conducts a recall, then the automotive index is comprised of the remaining five equally weighted auto companies. In the case where multiple firms announce a recall on the same day (i.e., Ford and Nissan), then the automotive index is comprised of the remaining four firms (GM, Chrysler, Honda, & Toyota) which did not announce a safety recall.

We opt to use an automotive index instead of the more traditionally employed value-weighted market portfolio for two reasons. First, we expect certain factors, such as changes to interest rates, oil prices and economic/political environment, to influence automotive companies more than the value-weighted market portfolio. Hence it seems reasonable to measure abnormal returns by using companies in the same industry. Second, we obtain higher R^2 estimations with an automotive index compared to the value-weighted portfolio.[19]

We use a simple abnormal returns calculation instead of the market model methodology, since we cannot assume that the beta estimates for each of these auto manufacturers are stable during the 26 year sample period.[20] For each recall by firm j the abnormal return, A_{jt}, is calculated by subtracting the equally weighted automotive market index, R_{mt}, for all automotive

[19] Higher R^2 are especially noticeable for Japanese ADRs which appear to move more closely with other automakers than the broader based market portfolio.

[20] See Brown and Warner (1985) for further discussion of this simple abnormal returns methodology.

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Table II. Adjusted 2-minus;day cummulative abnormal percentage return for automotive safety recalls: 1973–1998 ($n = 592$)

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error
Defective component										
Air bag	−0.6989*	(0.4136)	−0.7073*	(0.4232)	−0.7593	(0.4724)	−0.7487	(0.4876)	−0.7829	(0.4844)
Brakes	−0.1047	(0.2030)	−0.1365	(0.2074)	−0.1435	(0.2125)	−0.1714	(0.2149)	−0.1789	(0.2117)
Electrical	−0.1604	(0.3116)	0.1907	(0.3112)	0.1545	(0.3197)	0.1794	(0.3182)	0.1390	(0.3171)
Engine	−0.0470	(0.2008)	−0.0641	(0.2015)	−0.0552	(0.2172)	−0.0644	(0.2154)	−0.0718	(0.2148)
Equipment	0.4127	(0.3421)	0.3938	(0.3429)	0.3685	(0.3405)	0.3564	(0.3464)	0.3504	(0.3395)
Frame & Bumpers	0.4419	(0.3747)	0.4193	(0.3779)	0.3916	(0.3771)	0.3552	(0.3800)	0.3460	(0.3816)
Fuel & Exhaust	0.0421	(0.1873)	0.0283	(0.1912)	0.0765	(0.1988)	0.0643	(0.1991)	0.0587	(0.1975)
Heater,Defroster & A/C	0.7282**	(0.3444)	0.7243**	(0.3352)	0.8413***	(0.3505)	0.8345***	(0.3455)	0.8317***	(0.3418)
Latches & Locks	0.2665	(0.2758)	0.2593	(0.2825)	0.2172	(0.2871)	0.1924	(0.2864)	0.1946	(0.2883)
Seats & Seat belts	−0.0305	(0.2118)	−0.0554	(0.2158)	−0.0802	(0.2196)	−0.1032	(0.2219)	−0.1017	(0.2196)
Steering,Susp.,Wheels	−0.0036	(0.1996)	−0.0228	(0.2016)	−0.0271	(0.2082)	−0.0496	(0.2064)	−0.0571	(0.2081)
Recall characteristics										
One model-year-old	0.0796	(0.1907)	−0.0758	(0.1923)	0.0678	(0.1917)	0.0779	(0.1943)	0.0777	(0.1919)
Two+ model-year-old	−0.2120*	(0.1220)	−0.1821	(0.1272)	−0.1878	(0.1308)	−0.1610	(0.1355)	−0.1668	(0.1327)
Initial recall	−0.3036***	(0.1087)	−0.2891***	(0.1144)	−0.3293***	(0.1130)	−0.3169***	(0.1183)	−0.3163***	(0.1121)
ln vehicles repaired	−0.0308	(0.0316)	−0.0322	(0.0318)	−0.0317	(0.0322)	−0.0321	(0.0321)	−0.0332	(0.0319)
Announcement lag	0.0004	(0.0014)	0.0003	(0.0014)	0.0001	(0.0015)	−0.0002	(0.0015)	−0.0000	(0.0015)

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Company characteristics										
ln market cap.	0.0514	(0.0545)	0.0435	(0.0707)	0.1401*	(0.0819)	0.1835	(0.1307)	0.1462*	(0.0817)
AAA bond rating	−0.3016***	(0.1045)	−0.3211***	(0.1213)	−0.4950***	(0.1692)	−0.5147***	(0.1779)	−0.5157***	(0.1705)
Japanese manufacturer	–		–		–		–		−0.1630	(0.1830)
constant	0.0262	(0.5984)	−0.1980	(0.8179)	−0.3309	(0.9950)	−1.9166	(1.5983)	−0.3011	(0.9937)
Manufacturer fixed effects?	No		Yes		No		Yes		No	
Year fixed effects?	No		No		Yes		Yes		Yes	
R^2	0.049		0.052		0.088		0.092		0.090	

Note: Robust standard errors appear in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

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companies excluding firm j, from the daily return of the recalling firm, R_{jt}, where t denotes the time in trading days relative to the WSJ recall article:

$$A_{jt} = R_{jt} - R_{mt} \qquad t = -1, 0. \tag{1}$$

In other words, the abnormal return is the change in the stock price of firm j that cannot be explained by the overall movement in the automotive industry. The two-day cumulative abnormal return (CAR) is the sum of A_{jt} for $t = -1$ and $t = 0$. The mean abnormal return is the cumulative daily abnormal returns divided by two. To isolate the equity response of the recall announcement, seven recalls were omitted because these recalls occurred on consecutive days by the same manufacturer.

To determine whether competing firms benefit from another company's recall announcement, we calculate the 2-day cumulative abnormal returns for an automotive index. We then subtract the value-weighted NYSE/AMEX market index from the automotive index to calculate the abnormal returns. If other automakers benefit from the misfortune of the recalling company, then the automotive index should register significantly higher returns than the total market index. Moreover, such a result would make the automotive index an invalid benchmark for comparison. We find negative and insignificant abnormal returns of –0.12%, hence there is no evidence that competitor firms benefit from a recall announcement of a particular automotive company.[21]

1. INVESTOR EXPECTATIONS

The WSJ routinely reports vehicle hazards before recalls occur by reporting ongoing NHTSA safety investigations that could ultimately result in a recall. The following excerpt illustrates information being released by the WSJ prior to the official recall announcement: "In the (monthly summary) report, the agency also said it stepped up its investigation into charges that brake-backing plates in certain 1978–1981 General Motors Corp. cars are prone to corrode, potentially causing brake failure" (*Wall Street Journal*, 10 December 1985).

The abnormal dollar returns due to a WSJ announcement should reflect the change in expected cost of a recall. The expected cost of a recall is the probability of a recall times the present value (PV) of the expected recall cost given a recall denoted:

$$\text{Abnormal Dollar Returns} = Pr(\text{Recall}) * \text{PV}(E(\text{Recall Cost}|\text{Recall})) \tag{2}$$

[21] Barber and Darrough (1996) and Hoffer et al. (1988) also document insignificant responses of competitor firms to a recall announcement by a particular automotive company.

To find the change (Δ) in the above product we apply the product rule, which is the change in the probability of a recall multiplied by the level of expected cost plus the change in the expected cost times the level of the recall probability:

$$\Delta\text{Abnormal Dollar Returns} = \Delta Pr(\text{Recall}) * \text{PV}(E(\text{Recall Cost}|\text{Recall})) + Pr(\text{Recall}) * \text{PV}(\Delta E(\text{Recall Cost}|\text{Recall})) \quad (3)$$

Since a WSJ recall announcement should have little effect on the level of expected cost, we focus our attention on the first term, the change in the recall probability due to the WSJ announcement. The change in the recall probability is:

$$\Delta Pr(\text{Recall}) = 1 - Pr(\text{Recall just prior to WSJ announcement}) \quad (4)$$

Since government-initiated recalls (approximately one-third of the sample) typically involve either a preliminary investigation and/or an engineering analysis, we assume that investors are fully aware of these on-going investigations. Hence, the Pr (Recall just prior to WSJ announcement) uses historical recall averages conditional on the status of the government's safety investigation. In the earlier recall expectations section, we show that the expected probability of a recall given a preliminary investigation just prior to the WSJ announcement is 0.17. Substituting this value into Equation (4), we find: $\Delta Pr(\text{Recall}|\text{preliminary investigation}) = 0.83$. Likewise, since the expected probability of a recall given an engineering analysis just prior to the WSJ announcement is 0.20, the $\Delta Pr(\text{Recall}|\text{engineering analysis}) = 0.80$. Finally, if there is no on-going NHTSA safety investigation (i.e., manufacturer-initiated recalls) then we assume that the $Pr(\text{Recall}|\text{manufacturer-initiated}) = 0$. In other words, these events are considered complete surprises, represented as $\Delta Pr(\text{Recall}|\text{manufacturer-initiated}) = 1$. Substituting these changes in recall probabilities into Equation (3), yields:

$$\begin{aligned}\Delta\text{Abnormal Dollar Returns} = {} & 0.83 * \text{PV}(E(\text{Recall Cost} \\ & |\text{Recall \& preliminary investigation})) \\ & + 0.80 * \text{PV}(E(\text{Recall Cost}|\text{Recall \&} \\ & \text{engineering analysis})) \\ & + \text{PV}(E(\text{Recall Cost}|\text{Recall \&} \\ & \text{manufacturer-initiated})) \quad (5)\end{aligned}$$

Finally, we use the abnormal returns A_{jt} calculated in Equation (1) to represent the present value of the expected recall cost given the recall announcement and status of the government safety agency investigation (if any). We label this composite of changes the *adjusted abnormal returns* (or Adjusted A_{jt}) as:

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Table III. Real adjusted two-day cummulative abnormal dollar returns (in millions of 1983 dollars) for automotive safety recalls: 1973–1998 (n = 592)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error
Defective component										
Air bag	−136.444*	(78.058)	−144.402*	(80.113)	−154.435*	(88.949)	−161.883*	(90.854)	−159.551*	(90.958)
Brakes	−37.527	(34.669)	−39.793	(36.733)	−32.534	(36.814)	−34.023	(38.143)	−40.842	(38.190)
Electrical	−56.684	(85.117)	−47.847	(80.547)	−59.739	(83.429)	−48.906	(78.937)	−63.516	(84.667)
Engine	−9.737	(32.404)	−12.864	(33.235)	−11.528	(36.413)	−12.667	(36.520)	−15.519	(36.457)
Equipment	71.864	(55.337)	78.062	(56.823)	74.831	(55.940)	79.106	(57.800)	70.377	(56.377)
Frame & Bumpers	67.932	(57.225)	63.348	(57.959)	73.044	(59.820)	69.601	(60.217)	62.284	(61.017)
Fuel & Exhaust	14.238	(32.794)	12.082	(34.163)	23.509	(36.900)	22.958	(37.402)	19.422	(37.163)
Heater,Defroster &A/C	114.708*	(69.138)	117.877*	(67.857)	127.569*	(72.172)	132.835*	(70.154)	124.974*	(70.361)
Latches & Locks	20.948	(38.307)	21.709	(41.673)	13.014	(42.829)	17.397	(45.021)	7.544	(44.118)
Seats & Seat belts	−21.674	(33.041)	−25.753	(34.542)	−26.493	(34.929)	−29.569	(36.455)	−31.508	(35.750)
Steering,Susp.,Wheels	0.031	(34.481)	−0.351	(36.340)	1.659	(36.926)	1.961	(37.813)	−5.328	(37.539)
Recall characteristics										
One model-year-old	−5.130	(32.302)	−0.833	(32.648)	−12.081	(33.314)	−8.726	(33.519)	−9.817	(32.752)
Two + model-year-old	−27.152	(24.952)	−16.985	(23.430)	−28.325	(24.587)	−17.261	(24.886)	−23.489	(24.252)
Initial recall	−35.014*	(19.302)	−26.260	(18.256)	−33.949*	(19.734)	−25.267	(18.567)	−30.727	(19.092)
ln vehicles repaired	−0.750	(5.144)	−1.506	(5.373)	−1.410	(5.531)	−2.264	(5.382)	−1.706	(5.433)
Announcement lag	0.081	(0.196)	0.031	(0.198)	0.010	(0.225)	−0.028	(0.220)	−0.012	(0.222)

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Company characteristics										
AAA bond rating	−47.258**	(20.574)	−53.578***	(22.035)	−53.926*	(28.318)	−66.552**	(28.867)	−56.848*	(29.504)
Japanese manufacturer	–		–		–		–		−37.849	(36.804)
constant	44.263	(57.791)	3.484	(96.146)	49.107	(83.168)	7.819	(112.06)	66.767	(85.505)
Manufacturer fixed effects?	No		Yes		No		Yes		No	
Year fixed effects?	No		No		Yes		Yes		Yes	
R^2	0.041		0.049		0.067		0.076		0.070	

Note: Robust standard errors appear in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

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Appendix A. Adjusted two-day cummulative abnormal returns for automotive safety recalls: 1973–1998 ($n = 592$)

Dependent Variable:	Percentage CAR Model 6		Percentage CAR Model 7		Real dollar CAR Model 13		Real dollar CAR Model 14	
	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error	Coefficient	Robust Std. error
Defective component								
Air bag	−0.7437	(0.4859)	−0.7671	(0.4796)	−159.797*	(90.464)	−163.474*	(90.109)
Brakes	−0.1644	(0.2161)	−0.1697	(0.2167)	−32.262	(38.100)	−33.001	(38.283)
Electrical	0.1888	(0.3179)	0.2130	(0.3162)	−46.548	(77.463)	−42.611	(76.277)
Engine	−0.0535	(0.2200)	−0.0545	(0.2206)	−9.919	(37.527)	−9.787	(37.704)
Equipment	0.3595	(0.3461)	0.3626	(0.3440)	80.118	(57.636)	81.636	(57.405)
Frame & Bumpers	0.3580	(0.3823)	0.3472	(0.3849)	70.689	(60.447)	68.376	(60.763)
Fuel & Exhaust	0.0681	(0.2001)	0.0541	(0.2021)	24.077	(37.642)	21.587	(38.114)
Heater,Defroster &A/C	0.8364**	(0.3500)	0.8076**	(0.3567)	133.178*	(71.134)	129.154*	(71.220)
Latches & Locks	0.1865	(0.2853)	0.1732	(0.2835)	16.611	(44.929)	14.025	(44.991)
Seats & Seat belts	−0.1133	(0.2208)	−0.1226	(0.2226)	−32.025	(36.569)	−33.631	(37.030)
Steering,Susp.,Wheels	−0.0349	(0.2109)	−0.0344	(0.2118)	5.587	(38.939)	5.552	(39.128)
Recall characteristics								
One model-year-old	0.0720	(0.1942)	0.0359	(0.1969)	−9.643	(33.627)	−14.788	(34.373)
Two + model-year-old	−0.1905	(0.1485)	−0.2987*	(0.1666)	−24.074	(27.473)	−41.370	(32.534)
Initial recall	−0.3143***	(0.1180)	−0.2990***	(0.1175)	−24.979	(18.549)	−23.128	(18.511)
ln vehicles repaired	−0.0274	(0.0328)	−0.0368	(0.0337)	−1.326	(5.581)	−2.862	(5.524)
Percent repaired	−0.1963	(0.2546)	−0.1793	(0.2544)	−35.704	(48.932)	−33.436	(48.567)
Announcement lag	−0.0002	(0.0015)	−0.0002	(0.0015)	−0.052	(0.227)	−0.049	(0.225)
Government-initiated	–		0.2034	(0.1348)	–		32.588	(25.389)

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Company characteristics								
ln market cap.	0.1858	(0.1315)	0.1548	(0.1342)	–		–	
AAA bond rating	−0.5085***	(0.1775)	−0.5074***	(0.1777)	−65.038**	(28.727)	−67.386**	(28.903)
constant	−1.8483	(1.6046)	−1.4274	(1.6511)	16.588	(117.54)	21.282	(116.96)
Manufacturer fixed effects?	Yes		Yes		Yes		Yes	
Year fixed effects?	Yes		Yes		Yes		Yes	
R^2	0.092		0.096		0.077		0.079	

Note: Robust standard errors appear in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

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$$\text{Adjusted } A_{jt} = 0.83^* A_{jt|\text{pre}} + 0.80^* A_{jt|\text{eng}} + A_{jt|\text{man}} \quad t = -1, 0 \tag{6}$$

where $A_{jt|\text{pre}}$ represents the abnormal returns conditional on an open preliminary investigation; $A_{jt|\text{eng}}$ denotes the abnormal returns given an engineering analysis; and $A_{jt|\text{man}}$ indicates the abnormal returns for manufacturer-initiated recalls. Every recall is classified into one of three categories: preliminary investigation, engineering analysis, or manufacturer-initiated. Abnormal returns are only calculated for the chosen category (i.e., for a recall given a pending engineering analysis, only $A_{jt\backslash\text{eng}}$ is calculated, while $A_{jt|\text{pre}}$ and $A_{jt|\text{man}}$ equal 0). The two-day adjusted cumulative abnormal return (or Adjusted percentage CAR) is the summation of Adjusted A_{jt} for $t = -1$ and $t = 0$. We also calculate Adjusted real dollar CAR by multiplying the Adjusted A_{jt} by the CRSP market capitalization of the recalling company. We obtain real dollar values by using the Consumer Price Index with August, 1983 as the basis month.

Since auto manufacturers do not disclose the cost of each recall campaign, a regression with 2-day mean abnormal returns as the dependent variable and recall characteristics as independent variables will determine the relevant recall factors. We estimate the following function:

$$\text{Adjusted } A_{jt} = f(\text{direct costs, indirect costs}) \quad t = -1, 0 \tag{7}$$

where the direct costs of implementing a recall include notifying, inspecting, and repairing the defective units, and the indirect costs cover the reputation damage or loss in goodwill due to the recall. The direct recall costs rise with the number of vehicles corrected. In addition, repair costs likely differ between the defective components. Recall losses incurred that are not associated with administering a recall campaign are considered a loss in goodwill or a reputational loss. For example, firms with high quality reputations (i.e., *Japanese manufacturers*) or excellent financial ratings (i.e., *AAA bond ratings*) have the potential for larger recall-related goodwill losses.

Due substantial size differences among the automakers,[22] the abnormal returns estimations may suffer from heteroscedasticity. We use a Breusch and Pagan (1979) test for heteroscedasticity, which uses fitted values for every abnormal returns regression.[23] To summarize our findings, we cannot reject the constant variance hypothesis at the 1% significance level for the percentage abnormal returns estimates, however, for the real dollar abnormal returns regressions we overwhelming reject the constant variance assumption.

[22] For example, at the end of 1998, Nissan had the smallest market capitalization of approximately $7 billion and Toyota had the largest capitalization of $101 billion.

[23] This is the "hettest" command in STATA.

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Therefore, we use White (1980) robust standard errors in all estimations to address the existence of heteroscedasticity.

V. Results

Table I presents descriptive statistics for the 592 WSJ safety recall announcements between 1973 and 1998. The *adjusted percentage CAR* indicates small shareholder losses of −0.08% or a loss of $9.5 million (1983) dollars per recall. The average number of vehicles recalled is nearly a quarter million (233,724), yet the median recall is considerably smaller at about 51,000 units. The three most common defective components are *steering, suspension & wheels*, *fuel & exhaust,* and *brakes,* which comprise 20%, 19%, and 15% of all recalls, respectively. The three least frequent recalled components include *heater, defroster & A/C, air bag,* and *frame & bumpers*. Each of these component categories comprise about 2% of all safety recalls.[24]

Tables II and III present regression estimates using the *adjusted percentage CAR* and *adjusted real dollar CAR*, respectively. One advantage of the adjusted real dollar abnormal returns (in millions of 1983 dollars) is the ability to quantify the magnitude of recall-related shareholder losses.[25] For ease of comparison, models 8–12 on Table III are counterparts to models 1–5 on Table II since these models estimate the same variables and same fixed effects measures. Each table considers various specifications such as the inclusion of manufacturer and year fixed effects, in addition to the nationality of the manufacturer. Finally, the appendix reports estimation results for the recall initiator, number of vehicles recalled, and percentage of vehicles repaired. Hence, we estimate fourteen models, half using percentage returns and the remainder using real dollar returns.

We find two variables that are robust to model specification: *heater, defroster & A/C* and *AAA bond rating*. The results indicate that *heater, defroster & A/C* recalls have significantly smaller shareholder losses than the omitted component category of *visual systems* (i.e., defects in the windshield glass, windshield wipers, mirrors and sun-roofs). While the recall repair costs can vary substantially within a component category, we expect that the repair costs for the typical *heater, defroster & A/C* recall are comparable to the typical *visual systems* defect. In terms of product liability, however, a windshield-related defect may be a greater hazard and present a larger potential liability for a firm than a malfunctioning heater.

[24] NHTSA exhaust recalls only involve potential safety hazards, not emissions recalls administered by the EPA.

[25] We also find that nominal dollar returns yields similar results to real dollar returns, hence the nominal dollar estimations are omitted. These results are, however, available upon request of the authors.

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The other consistent result across all fourteen models is significantly larger shareholder losses for companies with a *AAA bond rating*. Companies in excellent financial shape (*AAA bond rating)* experience a loss of between −0.30% and −0.52% (or $47 to $67 million 1983 dollars) after a WSJ recall announcement. Larger shareholder losses for financially stable firms lends further support for the Barber and Darrough (1996) suggestion that the reputational penalty may comprise a substantial portion of the equity losses surrounding recall announcements since manufacturers with a reputation for producing high-quality vehicles suffer the largest losses.

We find one variable, *initial recall*, is robust across all abnormal percentage specifications (models 1–7). The *initial recall* of a make, model, and year has significantly larger shareholder losses, between −0.29% and −0.33%, than a recall involving the omitted component category: *visual systems*. We attribute this result to a loss in goodwill or reputation since the direct repair costs for models experiencing their *initial recall* should be comparable to models that have been previously recalled. Once again, it appears that the high quality manufacturers (in our case, producers of a make and model which previously had an unblemished recall history) experience the largest losses following a recall announcement. In the abnormal real dollar returns specifications (models 8–14), *initial recall* registers significant shareholder losses in only two of the seven estimated models.

We also find that one variable, *air bags,* yields a consistent result across all abnormal real dollar returns estimations. Recalls involving *air bags* are marginally significant and cost between $136 and $163 million (1983) dollars more than *visual systems*. As mentioned previously, an auto manufacturer may share the *air bag* recall-related costs with an outside supplier (i.e., TRW). We do not, however, adjust the abnormal dollar returns to reflect any cost sharing agreements. Nonetheless, auto manufacturers still experience a reduction in shareholder value due to *air bag* recalls. We also find marginally significant *air bag* losses in two of the seven models which use abnormal percentage returns.

Finally, there are two variables (*two+ model-year-old* and *ln market capitalization*) that obtain marginal significance in the abnormal percentage returns estimations. These results, how-ever, are sensitive to the model specification. For example, in model 1 (which excludes both manufacturer and year fixed effects) recalls involving *two+ model-year-old* vehicles have marginally larger losses (−0.21% than *current model year* vehicles. There are two plausible explanations for this result corresponding respectively to differences in repair costs and differences in liability costs. Hoffer et al. (1994) report that older models are, in fact, less likely to be repaired. This suggests that the higher costs to a firm associated with recalling older models may be the result of higher liability exposure, perhaps because consumer injuries have had more time to manifest. A similar result, larger losses for older

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models, is found in model 7 (which includes both fixed effects measures along with an indicator variable for the recall initiator). In the remaining five abnormal percentage specifications, model year age is insignificant.

The market capitalization of the recalling automotive company reaches marginal significance in models 3 and 5. These models include year fixed effects to capture any changes over time during the 26 year sample period and exclude manufacturer fixed effects. We find that firms with a larger *ln market capitalization* have slightly smaller losses following recall announcements than a smaller manufacturer. In the other five estimated models, firm size has no affect on abnormal percentage returns.

The discussion thus far has focused on the statistically significant variables. Also of interest are the variables that are not associated with significant shareholder losses, such as the number of *vehicles repaired, one model-year old, announcement lag* between NHTSA filing and WSJ announcement, and the remaining component categories: *brakes, electrical, engine, equipment* (*i.e., speed control, jacks, radio|cassette player, spare tire, etc.*)*, frame & bumpers, fuel & exhaust* , *latches & locks, seats & seat belts*, and *steering, suspension & wheels*. The insignificance of *vehicles repaired,* (which is the product of *vehicles recalled* and *percent corrected*), suggests that the direct repair costs of a recall are minimal. Since the number of *vehicles repaired* is unknown at the time of the recall announcement, we assume that investors forecast the number of expected vehicle repairs. To verify the robustness of these insignificant recall size results, we consider an alternative variable, the number of *vehicles recalled,* since this variable is known at the time of the recall announcement. We also include *percent corrected* in the estimations to proxy the perceived defect hazard. Neither the *ln vehicles recalled* nor the *percent corrected* provide much explanatory power (see the Appendix A). This finding lends further support for the claim that direct costs of a recall (i.e., vehicle repairs) are minimal.

We also examine whether the shareholder response differs based on the nationality of the manufacturer. Recalls by Japanese firms may be especially damaging since they have a reputation for making high quality vehicles. Models 5 and 12 reveal no evidence that *Japanese manufacturers* experience larger goodwill losses compared to their American counterparts. Finally, we examine whether the equity response differs based on which entity (manufacturer or government) initiates the recall campaign. Consistent with Rupp (2001), the Appendix A (models 7 and 14) shows that *government-initiated* recalls are neither more, nor less, damaging for shareholders than manufacturer-initiated campaigns.

To test the robustness of these results we consider an alternative specification, substituting the more traditionally used value-weighted market portfolio in place of the automotive market index, R_{mt}, in Equation (1). Next, we re-estimate each of the fourteen models using the

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value-weighted returns and find that the two-day cumulative abnormal returns for the value-weighted market portfolio provide similar returns.[26] We also find that most coefficient estimates have become smaller in absolute terms in the value-weighted market estimations. Given the empirical power is poor and since we can reject the possibility that competitor firms benefit from the recall announcement of another automotive company, we employ the automotive index as the comparison benchmark in calculating abnormal returns.

VI. Conclusion

While researchers have extensively documented the equity response to product recalls and the subsequent shareholder losses, less attention has been given in the literature to examining the damaging recall attributes. Using automotive recall data from 1973 to 1998, we find that recall attributes are important indicators of shareholder losses. After constructing an equally-weighted automotive market index to control for industry effects and adjusting abnormal returns for the degree of surprise in the *Wall Street Journal* announcements, the study estimates the effect of recalls on both percentage and real dollar abnormal returns.

The results indicate that shareholder losses are sensitive not to the size of the recall, instead we find that the defective component along with recall and company characteristics matter. Specifically, defective *heaters* are significantly less costly for shareholders, while in some instances *air bag* recalls lead to larger equity losses. There is also some evidence that suggests recalls of *two+ model-year-old* vehicles are more costly.

Our results are consistent with the Barber and Darrough (1996) claim that the reputational penalty comprises a substantial portion of the equity losses caused by recall announcements, since we find that the indirect costs of automotive recalls are likely larger than the direct costs. Specifically, we detect significant goodwill losses for the *initial recall* of a make, model, and year and for financially stable companies with *AAA bond-ratings*. Moreover, the number of *vehicles repaired*, *vehicles recalled*, and *percent repaired* provide little explanatory power of abnormal returns, which suggests that the direct recall costs are minimal. Equity losses for *Japanese manufacturers* are neither larger, nor smaller, than their American counterparts. Finally, we find no evidence that *government-initiated* recalls are more damaging for shareholders than manufacturer-initiated campaigns.

[26] The mean two-day value-weighted abnormal return is 0.0004%.

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