Costly External Finance, Regulatory Regime, and the Strategic Timing of Vehicle Recalls*

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Abstract

We examine how the timing of vehicle recalls depends on the quality of information that firms have about possible defects, the proactivity of the regulator (National Highway Traffic Safety Administration), and the need to raise external finance. We find that large recalls are timed strategically to minimize their impact on the cost of external finance. Our results suggest an important channel through which financial policy affects consumer welfare. This type of strategic timing of vehicle recalls also suggests that, contrary to company statements and some internal investigations about recent large-scale recall campaigns, top management is typically aware of product defects.

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1. Introduction

In 2014, General Motors (GM) recalled 29 million cars in North America in connection with faulty ignition switches. As is now well documented, GM had been aware of the ignition switch problem for more than a decade. A probe by U.S. Attorney Anton Valukas found that the switch issue lingered so long because of poor judgment by some employees and a lack of communication within the company. The investigation, however, completely absolved GM's top executives from responsibility, finding that the information about the problem did not reach them until January 2014.

While GM's failure to address the ignition switch problem (which, if handled in a timely manner, would have cost very little) and the associated accidents and fatalities attracted much attention, vehicle recalls are very common occurrences for major U.S. car manufacturers. Since 1966, the Big Three (GM, Ford, and Chrysler) have issued multiple recalls almost every year, totaling well over one thousand. (GM issued 45 recalls in 2014 alone.) While many of these recalls involved a relatively small number of cars, 724 recalls from January 1966 to July 2010 affected more than 100,000 defective vehicles. In this paper, we focus on larger recalls and provide evidence that the timings of these recalls are strategic decisions that have implications for shareholder wealth, by softening the impact on the cost of raising finance. Because considerations such as the cost of external financing in the decision-making process likely are not taken into account without the involvement of top-level management, one implication of our evidence is that information regarding vehicle defects that might necessitate recalls frequently reaches the top layers of management, contrary to what the specific GM incident might suggest.[1]

[1] In March 2014, Attorney General Eric H. Holder Jr. announced that Toyota had reached a $1.2 billion deal with the U.S. Justice Department to conclude a four-year criminal investigation for concealing information relating to

More generally, our results imply that firms' financial structure can affect management incentives to reveal information – especially information that is adverse.

When public interest dictates that private activity needs policing, a third player typically emerges, namely, the regulator.[2] In the context of vehicle safety, the relevant regulatory authority is the National Highway Traffic Safety Administration (NHTSA). However, many have questioned the role of NHTSA in connection with GM's recalls. For example, the agency received the first consumer complaints about the ignition switch as early as 2003 but repeatedly ignored them. A *New York Times* article summarized its findings of a detailed investigation into NHTSA's handling of major safety defects as follows.[3]

> An investigation by The New York Times into the agency's handling of major safety defects over the past decade found that it frequently has been slow to identify problems, tentative to act and reluctant to employ its full legal powers against companies… in many of the major vehicle safety issues of recent years—including unintended acceleration in Toyotas, fires in Jeep fuel tanks and air bag ruptures in Hondas, as well as the G.M. ignition defect—the agency did not take a leading role until well after the problems had reached a crisis level, safety advocates had sounded alarms and motorists were injured or died.

NHTSA's priorities arguably had changed during the last decade due to improved vehicle safety and lower incidence of fatalities. The agency was spending significantly more resources, for example, on generating a car safety ratings system (which manufacturers used for their marketing campaigns) than for investigating defects. We argue that another significant factor that affected regulatory proactivity was passage of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act (signed into law by President Bill Clinton on November 1, 2000). The act greatly increased the information-gathering and reporting

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faulty parts that caused sudden, unintended acceleration in several of its models. Investigators matched internal documents to the company's public statements and found that the company willfully downplayed the extent of the problem.

[2] Mitnic (1980) defines regulation as "the public administrative policing of a private activity with respect to a rule prescribed in the public interest."

[3] See "Regulator Slow to Respond to Deadly Vehicle Defects" by Hilary Stout, Danielle Ivory, and Rebecca R. Ruiz, in the September 14, 2014, edition of the *New York Times.*

requirements on manufacturers, which they might otherwise have found to be privately suboptimal. [4] However, while producing more information, the law also significantly increased the lag in reporting and the time it takes for the regulator to process information. [5,6] In addition, the combination of improved vehicle safety and car manufacturers having more information about potential vehicle defects as a result of the TREAD Act is likely to have created regulatory slack, with NHTSA relying more on the vehicle manufacturers to initiate timely recalls. Thus, while firms were forced to acquire and report more information on vehicle safely, proactive government-initiated recalls became less likely after enactment of TREAD, creating an opportunity for manufacturers to strategically delay their recalls if doing so was in their interest. In Subsection 5.4.1, we present several pieces of evidence suggesting that the post–TREAD period was one in which proactivity was lower relative to the earlier decade (i.e., the 1990s).

Unlike the GM and Toyota cases in which the defects were not addressed and complaints were ignored for long periods, a majority of even the larger recalls in our sample happened within two years from the start of manufacturing. However, because of the right-truncation problem, we may have not yet observed some potentially very large recalls. Therefore, making unconditional statements about the effect of firms' financial structure on recall timing or its likelihood is difficult. We therefore examine a setting in which financial structure can affect firms' incentives to delay or hasten recalls by at most only a few months. We consider how the amount of previously issued long-term debt maturing in a given year affects the likelihood of firms issuing recalls earlier than an arbitrary cutoff point in that year (for vehicles that began

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[4]The law also introduced criminal liability if information voluntarily withheld regarding defects subsequently caused injury or death.

[5] The NHTSA gives manufacturers 120 days after the close of a quarter to submit reports. The 120 days is meant to allow the manufacturers enough time to review and analyze the information they report.

[6] The TREAD Act introduced an early warning system (EWS) for potential problems. The richest and most effective data for the EWS are in text form, and they are composed of comments from repair technicians and customer complaints. Analyzing these data can be a time-consuming and challenging task.

being manufactured in that same year).[7] We find that after passage of the TREAD Act, when vehicle manufacturers were expected to have better information about vehicle defects but NHTSA became less proactive compared with the previous decade, manufacturers were more likely to initiate early recalls. However, the presence of larger quantities of maturing debt had the opposite effect on the incentive for making early recalls. Whereas, post–TREAD, more maturing debt led to later recalls, this was not the case in the decade before TREAD. The effect of maturing debt on recall timing allows us to identify a strategic recall timing effect related to regulatory proactivity that is separate from the effect of the TREAD Act on the incentives of firms to collect and process information on vehicle defects.

A possible alternative explanation for our results is that the distribution of informative signals observed by manufacturers is not independent of the level of maturing debt and that firms with higher levels of maturing debt receive these signals with delay. This could occur, for example, if firms with more maturing debt delay the launch of vehicles until after the debt has been paid. If this were the case, the positive effect of debt on delay would be expected to be stronger when the regulator is more proactive, which is the opposite of what we find. Moreover, why such an effect would hold in the post–TREAD period, and not the prior period, is unclear. Nevertheless, to directly address this issue, we obtain a sample of recalls that were preceded by serious consumer complaints to the NHTSA about vehicle safety (involving crash, fire, fatalities, or injuries). Such complaints necessarily occur after the product has been launched. An additional advantage of this sample is that the manufacturer has received some signal about a potential problem. We examine how the likelihood of a manufacturer-initiated recall one hundred days prior to the end of the year in which the first complain is received is affected by

[7] The cutoff point in our regressions is one hundred days before the fiscal year-end, which is roughly the midpoint between the commencement of manufacturing and the fiscal year-end. However, our results are robust to alternative cutoffs.

previously issued debt maturing at the end of that year. Our results on how the propensity to recall is affected by the level of maturing debt in the post– and pre–TREAD periods are very similar to those discussed above.[8]

To alleviate concern that our results could be driven by time series effects that are not associated with regulatory proactivity, we explore the effects of cross-sectional variations in NHTSA proactivity. To do so, we use the presence of a NHTSA regional office in a state as an instrument for proactivity. We posit that NHTSA will be more proactive vis-à-vis serious complaints that originate in states where it has a regional office. We further argue that while the agency is less likely to be proactive in a state if it does not have a regional office, this would be less likely to be the case if the complaint originates in a city within such a state with high population density (or population). As a result, higher levels of maturing debt would be associated with delayed recalls in states without regional offices, but the effect will be attenuated in cities within the state with higher population density (or population). We find very consistent results.

We develop a theoretical framework that captures how short-term financing needs affect firms' recall timing decisions, depending on the proactivity of the regulatory regime (Section 3). A key aspect of the argument is the notion that large-scale recalls are likely to be costly, especially if they occur prior to and near a time when the firm needs to raise external financing. Several costs are associated with recalls. First, there are reputational costs, because, by recalling, a firm admits that there is a problem.[9] Second, the recall campaign itself, and replacement of the

[8] Similar to Rupp and Taylor (2002), the assumption here is that, because manufacturers have better information in the post-TREAD period than in the earlier period, the regulator is less likely to be proactive in the later periodeven in these cases of serious complaints, and to expend resources in investigations that the manufacturer is unlikely to conduct (e.g., older models in which liability may have already been incurred or smaller recalls).

[9] In the U.S. Justice Department case against Toyota, prosecutors said that Toyota concealed problems related to floor mats and sticky accelerator pedals and made misleading statements to consumers in an effort to defend its brand image.

defective parts, can be expensive. Third, sales could freeze while the recall and replacement of the parts are under way, and the firm could lose customers who cannot wait and opt for competitors' products.[10] All of these costs are likely to matter more if the firm needs to raise external financing. For example, reputational costs or the loss of revenues can adversely affect the cost of raising new financing.

Figure 2 shows that large recalls are associated with industry-adjusted sales declines in the recall quarter and the subsequent quarter, suggesting that recalls can be costly in terms of lost revenues and reduced internal cash flows, which may matter if the recalls occur just before firms have relatively inflexible external financing needs, such as debt coming due. In Table A4 in the Appendix, we present evidence that, in the presence of higher amounts of maturing debt, firms associated with larger recalls are more likely to experience ratings downgrades.

Figure 3 provides further evidence that firms try to avoid recalls prior to issuance of debt and equity. For relatively larger manufacturer-initiated recalls (Panel A), issuance activity peaks immediately before the recalls. For regulator-initiated recalls (Panel B), issuance activity peaks a few months before the recalls, as the timing of a recall is not entirely in a firm's control when an investigation is ongoing. Firms thus try to bring forward their issuance activity given the risk of a regulator-initiated recall immediately before financing is needed. These Figures are discussed in greater detail later.

Our paper is related to several strands of literature. Finance researchers have proposed a number of ways in which a firm's financial structure affects aspects of its operations. For example, debt affects product market strategies (Brander and Lewis, 1986; Chevalier, 1995; Dasgupta and Titman, 1998), product quality (Maksimovic and Titman, 1991), and investment

[10]Several studies document that vehicle recalls are associated with negative stock price reactions and find that the wealth losses on average exceed the losses due to the direct costs of recalls (see, for example, Jarrell and Peltzman, 1985).

(Myers, 1977; Jensen and Meckling, 1977). We add to this literature by showing that financial structure also affects how firms choose the timing of product recalls, which is likely to have major implications on consumer welfare. We also address the literature on product recalls, which has focused mainly on the stock market's reaction to product recall announcements (Jarrell and Peltzman, 1985; Pruitt and Peterson, 1986; Hoffer, Pruitt, and Reilly, 1988; Dranove and Olsen, 1994; Barber and Darrough, 1996; Chu, Lin, and Prather 2005).[11] An interesting finding in this literature is that the loss in shareholder wealth exceeds the direct costs of recall, indicating that there are other costs.[12] We find that large recalls are associated with a higher likelihood of ratings downgrades for firms with high levels of maturing debt. This suggests that the higher cost of external finance is a possible explanation for the loss of firm value beyond the direct costs of recall. Finally, our results address the literature on government-mandated information disclosure. The effects of mandating disclosure of information about product quality have been studied in such contexts as restaurant hygiene grade cards (Jin and Leslie, 2003), nutritional labeling requirements (Mathios, 2000), and environmental safety (Bennear and Olmstead, 2008). We examine a different setting, i.e., mandatory reporting of information that is primarily generated through a vehicle manufacturer's own effort.

The rest of the paper is organized as follows. Section 2 provides an overview of the vehicle recall process and regulation. Section 3 presents a model, and Section 4 describes our data. Section 5 presents our empirical results, and Section 5 concludes.

2. Motor Vehicle Recalls

The National Highway Traffic Safety Administration requires a vehicle manufacturer to initiate a recall in the following two scenarios. First, a motor vehicle or motor vehicle equipment

[11] Kini, Shenoy, and Subramaniam (2013) examine recall events of a large variety of products. Among several other findings, they document that recalls are associated with sales declines and increases in advertising expenditure.

[12] The direct costs include lost demand, inventory losses and refund, litigation, and remedying the defective product.

(including tires) does not comply with Federal Motor Vehicle Safety Standards.[13] Second, the vehicle or equipment has a safety-related defect.[14]

Either the manufacturer or the NHTSA can initiate investigations on vehicle safety. Most decisions to conduct a recall and remedy a safety defect, however, are manufacturer-initiated, that is, the manufacturer voluntarily launches an investigation. Through its own tests, inspection procedures, and information-gathering systems, the manufacturer often discovers that a safety defect exists or that the requirements of a federal safety standard have not been met. The manufacturer is obligated to report such findings to the government and take appropriate action to correct the problem. In this paper, we call such recalls *manufacturer initiated recalls*.

The NHTSA Office of Defects Investigation (ODI) is responsible for collecting complaints regarding vehicle safety defects. If the agency receives similar reports from a number of people about the same product, an investigation is opened. After preliminary investigation, the NHTSA may decide that no defect exists and the case is dropped. If the agency decides that further investigation is warranted, then the investigation is escalated and an engineering analysis is conducted.[15] At any point during the NHTSA investigation, the manufacturer can initiate a recall based on its own investigation and information. Recall campaigns in which the investigation is initiated by the NHTSA are called *government initiated recalls* in this paper.[16]

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[13] The standards set minimum performance requirements for those parts of the vehicle that most affect its safe operation or that protect users from death or serious injury in the event of a crash. These standards are applicable to all vehicles and vehicle-related equipment manufactured or imported for sale in the United States and certified for use on public roads and highways.

[14] Generally, a safety defect is defined as a problem posing a risk to motor vehicle safety that exists in a motor vehicle or motor vehicle equipment or in a group of vehicles of the same design or manufacture or items of equipment of the same type and manufacture.

[15] Rupp and Taylor (2002) report that about half of the cases are closed following a preliminary investigation, whereas 10% result in recalls and another 40% are escalated. About a third of the cases subject to laboratory testing result in recalls.

[16] Both manufacturer- and government-initiated recalls are considered voluntary. It is uncommon for the NHTSA to order a manufacturer to issue a recall. This process usually involves a lengthy hearing process and may end in litigation.

The TREAD Act, representing a major step in the evolution of product safety regulation, was enacted in 2000 in response to the significant number of injuries and fatalities associated with Ford Explorers fitted with Firestone tires. The law requires manufacturers of vehicles and vehicle parts to submit two sets of reports to NHTSA on a quarterly basis. The first contains death and injury reports, of which the manufacturer has knowledge, caused by the manufacturer's product. The second consists of reports of warranty claims, production volumes, damage, recalls, repair and replacement activities collected from field reports (e.g., from repair technicians, dealers, and customers), consumer advisories, and customer complaints. In addition to the general data requirements, NHTSA may ask for more detailed information from the manufacturer as necessary for its investigation. The firm is required to maintain a TREAD picture at all times.

Of the law's several components, the early warning requirement is perhaps the most significant from the perspective of product recall incentives of vehicle manufacturers. Manufacturers have to report to the NHTSA information on defective products or product parts, incidents such as accidents or deaths, and other relevant data in a timely manner. Criminal liability results if information voluntarily withheld regarding defects subsequently leads to injury or death.

A couple features of the reporting requirements under the TREAD Act are worth emphasizing. First, the time lags involved in the reporting of information can be long. NHTSA gives manufacturers up to 120 days from the end of a quarter to submit a report. This effectively means that an incident that occurred in the first quarter could be reported in the third quarter, thus allowing a manufacturer to delay reporting if it is in its interest to do so. Second, the volume of information that needs to be reviewed can be substantial, for both the firm and the regulator. Some of the most useful information comes from field reports, which are in unstructured text form. A typical automotive manufacturer can produce incident reports that can run into millions of pages.

We argue in this paper that while the TREAD Act greatly enhanced information production, it also slowed the speed of regulatory response to incident reports made directly to the regulator. Given the substantial volume of information and the built-in lags in reporting, the process mandated by the TREAD Act may have created opportunities for strategic delay by the manufacturers.

3. A Model of Product Recall Timing

In this section, we develop a simple model to derive some implications as to how external financing needs, information quality, and regulatory regime jointly determine the timing of product recalls. We first set up a preliminary model to highlight some of the trade-offs involved and then extend the model to obtain a richer set of implications.

3.1 Preliminary Setup

In the timeline for the preliminary model (Panel A of Figure 1), assume that a product is defective with probability α. The manufacturer, at an initial time t_0, can observe one of two possible signals. Conditional on the product being defective, the firm privately observes a signal d with probability ϕ, where $1 \geq \phi \geq 1/2$. Conditional on the product being safe, a signal s is observed with probability ϕ (and d observed with probability $1-\phi$).

[Insert Figure 1 near here]

The posterior probability that the product is defective when d is observed is thus:

$$p = \text{Prob.}[\text{defect}|d] = \frac{\text{Prob.}[d \mid \text{defect}].\text{Prob}[\text{defect}]}{\text{Prob.}[d \mid \text{defect}].\text{Prob}[\text{defect}] + \text{Prob.}[d \mid \text{safe}].\text{Prob}[\text{safe}]}$$

$$= \frac{\phi\alpha}{\phi\alpha + (1-\phi)(1-\alpha)}. \quad (1)$$

Note that p is increasing in ϕ and in α.

The state (whether the product is safe or defective) will be publicly revealed at some time $t \geq t_0$. The firm can recall the product now (i.e., at t_0) after observing the signal, at a cost c_0, or postpone the decision until t. We assume that the firm will have to recall the product if it is revealed to be defective. The cost of recall at t is $c > c_0$. The cost is higher if the recall occurs later because the more the firm delays the recall, the more the number of units affected, conditional on a defect.[17] More generally, we could assume the following:

A1. *The cost of recall is increasing in the recall size. Thus, for a given rate of sales per day, it is increasing in the recall delay. For a given delay, it is increasing in the rate of sales.*

Suppose signal d is observed at t_0. If a firm recalls immediately, the payoff is $-c_0$. If it waits until t, when the state is fully revealed, its ex ante payoff (as of t_0) is $-cp$. Clearly, it recalls immediately if and only if $c_0 < cp$. (It is easy to show that the firm never recalls immediately after observing signal s if it would never have recalled immediately in the absence of a signal, which we assume.)

From this, two preliminary observations follow.

(i) If the signal is very imprecise, p is low, and the firm will not recall immediately.

(ii) For any signal precision, a higher c will make it more likely to recall immediately.

One reason that c could be high is the presence of debt due to mature immediately after t. These results may help explain why a firm with low-quality signal does not recall immediately if it has no debt but may do so if it has high levels of debt maturing immediately after t.

3.2 Regulatory Regime, Information Quality, and Recall Incentives

[17] A later recall could also prove more costly in terms of lost sales following the recall announcement if it occurs when the rate of sales has peaked.

We now extend the above model by introducing a regulator and allowing information quality to be correlated with the regulatory regime.

Assume that there are two possible levels of signal precision, $1 \geq \varphi_1 \geq \varphi_2 \geq 1/2$. Let μ denote the probability of the higher-precision signal. Further assume that, in the post–TREAD period, firms are more likely to have the more precise signal than in the pre-TREAD period (the decade of the 1990s), that is, μ is higher in the post–TREAD period. Firms receive a signal at time t_0.

When the average information quality possessed by firms is better, the regulator is less likely to be proactive. This might take the form of the regulator being less involved in conducting its own investigations. We model this by assuming that, if the product is defective, the true state is less likely to be publicly revealed at some interim time in the post–TREAD period than in the pre–TREAD period.

Specifically, in the post–TREAD period, with probability δ, the state is *privately revealed* to the firm at time $t_1 > t_0$. The recall cost at this point of time if the firm has no maturing debt is c_1. The true state will be publicly revealed, with probability one, at a later time t_2. The cost of recall then is c_2. We assume $c_0 < c_1 < c_2$. These assumptions about cost are consistent with Assumption A1 above.

We assume that if the firm has any maturing debt, then the debt matures between t_1 and t_2. If the firm initiates a recall at t_1 and has maturing debt, then the recall cost increases to $c' > c_2$. This assumption captures the idea that a recall imposes additional costs if a firm has to raise external financing immediately after the announcement. Panel B of Figure 1 presents a timeline for the extended model in the post–TREAD period.

Matters are similar for the pre–TREAD period except for one difference: The state is *publicly revealed*, with probability δ (as for the post–TREAD period), at t_1. If not, it is publicly revealed, with certainty, at t_2. This assumption captures the idea that the regulator is more proactive in the pre–TREAD period (given the lower average quality of signals in this period and, consequently, more delayed recalls, as will be seen below). Panel C presents a timeline for the pre–TREAD regime. The only difference with the post–TREAD regime is that the signal at time t_1 is publicly revealed with probability δ instead of being privately revealed with probability δ.

Consider first the firm's recall decision when there is no maturing debt. If the firm does not recall at t_0, and the state is privately revealed at t_1, the firm will recall immediately if there is a defect. If, instead, the state is publicly revealed, the firm will be asked to recall immediately.

Thus, in either regime, the expected future recall cost from not recalling at time t_0 when the firm receives an adverse signal is $p\ (\delta c_1 + (1-\delta)\ c_2)$. Thus, the firm will recall at t_0 in either regime if and only if $c_0 < p\ (\delta c_1 + (1-\delta)\ c_2)$. We assume:

A2. $$p_2(\delta c_1 + (1-\delta)c_2) < c_0 < p_1(\delta c_1 + (1-\delta)c_2)$$

where p_i is obtained from equation (1) with ϕ replaced by ϕ_i.

Thus, in the absence of maturing debt, firms with low-quality signals will wait and those with high-quality signals will recall at t_0, in either regime. Since the probability of a high-quality signal conditional on a defect is higher in the post–TREAD regime, it follows that earlier recalls will be more likely when the firm has no debt in this regime.[18]

The presence of maturing debt can change the trade-off for firms with lower-quality signal. To see this, assume

A3. $$p_2(\delta c' + (1-\delta)\ c_2) > c_0 > p_2 c_2.$$

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18 The probability of a recall, given a defective product, is $\mu + (1-\mu)p$, and the fraction of early recalls is $\mu/[\mu + (1-\mu)p]$, which is increasing in μ.

In the pre–TREAD regime, the recall decision of the firm changes: since $p_2(\delta c' + (1-\delta)\ c_2) > c_0$, this firm now will recall at t_0. However, in the post–TREAD regime, the decision of the low signal quality firm to delay recall need not change even with debt, if $p_2 c_2 < c_0$, since the signal at t_1 is private. Thus, this firm will now recall even later (at t_2), and the recall will be a public recall (since at t_2 the signal is publicly revealed).

To summarize, our model has two testable implications:

Implication 1. For firms with low levels of maturing debt, recall delays will be shorter during periods when the average signal quality with firms is higher (and the regulator is less proactive) than during periods when the average signal quality is worse (and the regulator is more proactive).

Implication 2. Higher levels of debt maturing in the near term will affect product recall timing. It will lead to earlier recalls if the regulatory regime is sufficiently proactive (in response to lower average signal quality with the firms) and delayed recalls if the regulatory regime is not very proactive (in response to higher average signal quality with firms). [19]

4. Data

Our data come from the monthly recall reports submitted since 1966 and recorded by NHTSA. Generally, each monthly report is made available to the public at the end of the first week of the following month. The monthly report contains the following details that are useful in our study: NHTSA campaign number, vehicle or equipment make, vehicle or equipment model and year,

[19] In the model, the informative signal occurs at date t_0. If we allow informative signals to occur at other points of time, it is possible that relative to the case of no debt, recall could be delayed when there is debt even in a more proactive regime. This is because recalling immediately before time t_1 would be associated with higher costs when there is debt, which could be larger than the expected cost of waiting, if δ is not one. This feature is not modeled here but could be easily introduced. Thus, a finding that more debt leads to earlier recalls in a more proactive regime at best is consistent with our theory, but not necessarily implied by it.

component description, the name of the manufacturer that filed the report, beginning and end date of manufacturing, potential number of units affected, date owners are notified by the manufacturer, and recall initiator. By constructing a web crawler to extract the monthly recall reports on its website, NHTSA makes the above statistics available on its website.[20] Under each recall campaign number, NHTSA creates multiple entries if more than one model type sold by a manufacturer or several components installed into one vehicle were affected, so multiple entries can be attached to a single campaign number. For instance, on January 21, 2010, Toyota Motor North America Inc. recalled vehicles of different model types for accelerator pedal problems. For this campaign, NHTSA created 24 entries to distinguish model types, including manufacturing years, for a total of 2,230,661 Toyota automobiles to be recalled.

For our sample period, out of a total of 84,580 entries, we delete 24,277 entries that do not record the date at which the manufacturing of the defective products begins, and we collapse the remaining 60,303 into recall files based on their unique campaign number. This leaves 11,521 recall files.

We next delete recall files that do not have information regarding the date at which recall occurs and the total number of units affected, as well as those that involve recalls that were launched prior to the recorded beginning of manufacturing date. As a result, 11,492 recall files are left. We also identify potential recall duplicates that involve the same recall but different defective components. There are 63 such recall files. Because in our tests we control for the type of component affected, we randomly select the affected components for the duplicate recalls.

Table A1 in the Appendix, for every five-year period from January1966 to July 2010, reports the number of recall campaign files and the potential number of units affected. The

[20] http://www-odi.nhtsa.dot.gov/downloads/flatfiles.cfm.

statistics show an increasing trend of vehicle safety-related recalls in terms of frequency and scope. Table A2 summarizes the recall characteristics over defective components.[21] Service brakes, equipments, and fuel systems, in that order, are the most common components that are responsible for safety-related recalls.

To match COMPUSTAT data with the NHTSA recall database, we check the company website or Bloomberg Businessweek (http://www.businessweek.com/) for the name of every vehicle firm appearing in each recall file to identify whether the company was publicly listed or was affiliated with a listed company. Among the 1,548 different names for recalling firms that appear in the NHTSA monthly recall reports, we identify three hundred as belonging to the headquarters or divisions of 149 different public firms and 14 as subsidiaries of ten public firms for which we can identify the exact year that the subsidiary was acquired.[22]

We further restrict our sample to firms that have Global Company Key (GVKEY) either in COMPUSTAT North American or Global. We then create a panel data set by matching financial data with NHTSA recall files based on firm GVKEY and fiscal year. We delete observations that do not have financial data as of the beginning of the manufacturing year, including the current portion of long-term debt, long-term debt due beyond one year, EBIT (earnings before interest and taxes), sales growth rate, cash and short-term investments, inventory, and total asset. We also exclude observations that do not have information regarding the state or country of incorporation. Our final sample has 5,831 recall files initiated by 118 public firms. Table A3 in the Appendix provides an overview of the steps in our sample construction.

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[21] NHTSA clearly states that defects such as “air conditioners and radios that do not operate properly” or “excessive oil consumption” are not considered safety-related. Thus, all the components mentioned in the recall campaign files either have safety problems or do not comply with safety standards.

[22] We delete recall files initiated by subsidiaries if we do not know the exact date when the subsidiary was acquired. This date is important because, for our tests, we control for characteristics of the company that initiates the recall.

Our analysis focuses on vehicle manufacturers, not parts suppliers. This is because, as a category, vehicle manufacturers are more homogenous, and the recalls involve vehicle recalls (90% of which are cars). This is important because the size of the recall (the number of units affected) is likely to matter for the timing of a recall, and some degree of homogeneity of the product being recalled is necessary for the number of units affected to correctly identify recall size. We thus check the description of the product for each public firm on its company website to determine whether the firm is a parts supplier or a manufacturer. We identify 53 public manufacturers.[23]

Table 1 shows how the manufacturing firms in our sample are distributed over various stock exchanges. The 53 firms come from nine stock exchanges, associated with a total of 5,295 safety-related recalls in the United States over the past 54 years. Among them, 26 (49.06%) are NYSE-listed firms, nine (16.98%) are listed in Japan, and five (9.43%) are listed in Germany, and they are responsible for 69.97%, 8.33%, and 9.27% of the total recalls events, respectively.

[Insert Table 1 near here]

5. Preliminary Analysis

In this section, we first present some descriptive statistics for our regression sample. We then consider evidence suggesting that large recalls are costly, especially when firms have large amounts of previously issued debt maturing in the same year. Finally, we offer some especially striking evidence indicating that when large issuances of debt and equity and large recall announcements occur in close temporal proximity, they are sequenced in such a way that the adverse consequences of recalls on the cost of finance is avoided.

5.1 Descriptive Statistics

[23] Another reason to exclude recalls initiated by parts suppliers is that it is unclear to what extent these recall decisions are independent decisions, as opposed to decisions imposed by a principal customer (i.e., a vehicle manufacturer).

Panel A of Table 2 presents descriptive statistics for the entire sample that meets all our data requirements as described in Section 4. The subsample in Panel B has recalls for which a variable (*Rate*) that represents the rate of sales of the affected vehicles prior to the recall exceeds the 75th percentile value of the corresponding distribution for the sample considered in Panel A. *Rate* is defined as the number of vehicles (units) affected by the defect divided by the number of days from the beginning of manufacturing to the date of recall (recall delay). In our sample, this variable is highly positively correlated with recall size, with a correlation coefficient of 0.87. Our main regression results are based on the sample in Panel B.

[Insert Table 2 near here]

The motivation for using the 75th percentile cutoff value of *Rate* for our regression sample is as follows. The sample of recalls in Panel A contains a number of small recalls (that is, the estimated number of vehicles affected is small), which are not as relevant in terms of their financial impact and, hence, should be excluded from consideration of the strategic timing of recalls. However, the number of units affected is clearly endogenous to recall timing: the longer a firm waits, the more the potential number of units affected. The manufacturer is likely to have less flexibility in controlling the rate of sales due to inflexibility in production schedules and inventory costs. Moreover, because the most important cost of recalls is likely to be interruption or loss of sales, the average number of units sold per day seems an appropriate choice for a sample of recalls that are subject to strategic recall timing. [24]

[24] All results reported in the paper hold (often at higher levels of significance) if, instead of sorting the subsamples on the basis of *Rate*, we sort based on *Rate* scaled by the total number of units produced by the firm. However, our sample sizes are about 30% larger when we sort on the basis of *Rate*. Results for the alternative sorting variable are available upon request. For the construction of this variable, we use data on annual unit sales, estimated based on information on annual sales and firms' market shares reported in *Ward's Automotive Yearbook*. However, this estimation is likely to be imprecise.

The upper section of each panel in Table 2 reports characteristics of the recalls. With one hundred days from the fiscal year-end of the year in which manufacturing begins as the cutoff for early recalls, about 22–24 percent of the recalls occur before then. The mean recall delay, measured from the first date manufacturing begins for any of the vehicles in the same recall file to the date of recall, is around three hundred days for both samples. Not surprisingly, the average number of units affected in a recall file is higher for the sample in Panel B. The mean number of units affected for the Panel B sample is almost 100,000 units. The distribution of the number of units affected is extremely skewed to the right for both samples. Around 7 percent of the recalls are government-initiated. However, the percentage of such recalls is higher for Panel B, which is made up of the larger recalls.[25] The mean number of models per recall file is around four, and the median is two. The mean number of days since the beginning of manufacturing to the end of the fiscal year is around 230 days, suggesting that manufacturing commences toward the beginning of the year. Thus, the one hundred days from the end of fiscal year cutoff is approximately the midpoint from the start of manufacturing to the end of the fiscal year on average.

The lower section in each panel reports the financial variables for the vehicle manufacturers involved in recalls. Firm characteristics are very similar for both samples, consistent with the fact that the same manufacturer is often involved with multiple recalls that belong to each sample in a majority of the years. (discussed further below). The mean, median, and standard deviation of debt maturing within the year divided by the book value of assets are all 5 percent.

Table 3 provides information on how frequently manufacturers recall vehicles, based on the year in which the manufacturing of the recalled vehicles commenced. We report statistics for

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[25]This is consistent with the notion that the manufacturers are less inclined to initiate larger costly recalls (Rupp and Taylor, 2002).

the Big Three manufacturers in the United States, Japan, and Germany separately, as well as other manufacturers in our sample and the overall sample. An important observation is that the major manufacturers almost every year produce a vehicle that is eventually associated with a recall (many, however, are small recalls in terms of the number of units affected). For the average sample firm, this happens in 76 percent of the manufacturing years. Thus, it is hard to argue that the debt due to be repaid will be managed in anticipation of a vehicle launch and a potential recall. The table also shows a related feature of the data: Firms typically issue multiple recalls in a given year. On average, for the typical firm, three different recall announcements occur for different batches of vehicles that were manufactured in the same year (many, however, are small-scale recalls).

[Insert Table 3 near here]

5.2 The Financial Impact of Recalls

Previous studies have documented stock price declines around recall announcements, confirming that recalls are costly.[26] Here, we examine how recalls affect sales and credit ratings.

In Figure 2, we plot median three-digit standard industrial classification industry-adjusted quarterly sales growth of firms that initiate recalls. We consider both manufacturer- and government-initiated recalls. The sample has many small recalls, so we focus on the larger recalls relative to the firm's size (measured in terms of the number of employees). In Panel A, the event date is the quarter in which the total number of units affected by the defect scaled by the number of employees (*QRatio*) exceeds the median. In Panel B, the cutoff is the 75th percentile of the distribution. The panels show a similar pattern. The industry-adjusted sales growth of the recalling firm drops sharply in the quarter immediately after the recall quarter and

[26] See, for example, Jarrell and Peltzman (1985), Pruitt and Peterson (1986), Hoffer, Pruitt and Reilly (1988), Dranove and Olsen (1994), Barber and Darrough (1996), and Chu, Lin, and Prather (2005).

then rebounds. It again drops after six quarters, possibly reflecting the fact that sales taper off after the launch of new models that were subject to an earlier recall.

[Insert Figure 2 near here]

In Table A4 in the Appendix, we present evidence that, in the presence of higher amounts of maturing debt, firms associated with larger recalls are more likely to experience ratings downgrades. Again, we consider both manufacturer- and government-initiated recalls. The dependent variable is one if the firm has a Standard & Poor's rating on long-term debt in the year after the recall year that is lower than that in the year before the recall year. *Big* is a dummy variable that takes the value of one if the total number of units affected by all recalls by a firm in a given year, scaled by the firm's number of employees, exceeds the median of the distribution. In our specification, we use the *Big* dummy, its interaction with a dummy variable (*H1*) that equals one if the level of maturing debt exceeds the 50th percentile of the distribution for our sample of vehicle manufacturers with credit ratings, and *H1* itself. Column 1 presents results from a probit model, and Column 2 presents the probit marginal effects. The corrected marginal effect for the interaction term is computed using Stata's "inteff" command and is shown in curly brackets. Columns 3 and 4 present results from a linear probability model, with firm fixed effects in Column 4. The interaction of *Big* and the high maturing debt dummy is significantly positive in all regressions. The results indicate that, in the presence of high levels of maturing debt, big recall years are associated with a higher probability of a rating downgrade. The marginal effect is substantial. The probability of a rating downgrade is higher by 30 percentage points (22–23 percentage points) as seen from Column 2 (Columns 3 and 4) for firms associated with big recalls in a particular year when the level of maturing debt exceeds the median.

5.3 Financing Activity around Recall Decisions

In Figure 3, we present preliminary evidence on firms' incentives to time recall announcements to avoid a potentially adverse impact (as evidenced by the effect of big recalls on credit ratings) on the cost of external finance. We examine, for our sample of recalls that are above median in terms of size (number of units affected by the recall scaled by the number of employees, labeled *Ratio*), firms' issuance activity regarding equity and public debt relative to the recall month. We restrict attention to relatively large issuances. For public debt issuances, the cutoff is 1.5% of the book value of assets, and for equity issuances, it is 3% of the book value.[27]

[Insert Figure 3 near here]

The evidence is striking. For manufacturer-initiated recalls, the number and median volume of issuance one month prior to the recall month dramatically increased relative to three months before. This is exactly what we would expect if firms delay recalls to avoid disruptions to capital-raising activity. Our model also predicts that, in a proactive regulatory regime, firms might recall early to preempt a regulator-initiated recall just before they plan issuance. Thus, we expect issuance activity to be high immediately after a recall for firms under such a regime, and the evidence in Figure 3 is consistent with this implication. In Panels C and D, we show issuance activity around government-initiated recalls. Here, the firm has less discretion over the timing, although it is aware of an ongoing investigation and whether a recall is to be expected in the near term. Firms engage in more frequent and larger volume of issuance activity somewhat earlier than the recall month compared with the situation for manufacturer-initiated recalls, possibly due to the uncertainty about the exact timing of the recall. Interestingly, because there is no preemptive early recalls in these cases, the issuance activity immediately after the recalls is lower than two or three months before.

[27] For equity issuances, McKeon (2011) argues that smaller issue sizes often represent internal equity issuances such as the exercise of employee stock options and advocates a cutoff around 3%.

5.4 Financial Structure, Regulatory Regime, and Firms' Incentives to Recall

The NHTSA's role in recent vehicle safety issues has been under considerable scrutiny. The agency in charge of ensuring vehicle safety allegedly has been insensitive to consumer complaints, reluctant to enforce its legal powers, quick to stop investigations even when the manufacturer has been preparing to present evidence, and too obliging in granting requests for scaling down the scope of recalls (only for these to be later expanded to much larger scale involving other models). Some have argued that safety investigation has been very far from NHTSA's mindset in recent years.[28] They say that the agency is more interested in helping car manufacturers sell cars by touting the safety of their vehicles under the agency's seal of approval. While the agency's budget for safety defects investigation has been around 1 percent of its total budget for each of the last six years, the share of funding for its ratings program as well as other divisions has increased.[29]

In the next subsection, we document three types of evidence suggesting that the post-2000 period was associated with less regulatory proactivity than the preceding decade. Some of the evidence indicates that this shift occurred soon after the passage of the TREAD Act, implying that the act itself, paradoxically, created an environment that encouraged regulatory slack. One reason that this could happen is that with the law requiring vehicle manufacturers to

[28] In one particularly striking revelation during his congressional testimony in 2014, David Friedman, the agency's acting head, indicated that he did not realize the agency could issue subpoenas to obtain information from vehicle manufacturers, suggesting that safety investigation was very far from the mindset of NHTSA's leadership. The lack of will to enforce safety was also evident in the fact that NHTSA made it optional for vehicle manufacturers to respond to a key question that they could be asked for defect claims associated with deaths or serious injuries, namely, "What may have caused the accident?" A *New York Times* investigation found that in only four out of one hundred cases did a manufacturer respond to the question and that there were no cases in which a defect in the vehicle was identified.

[29] According to a *New York Times* article, even though the agency's defects office added more staff soon after the TREAD Act was enacted in response to the need for analysis of much higher volume of data reporting, growing to 63 employees at one point in 2001, the number was allowed to shrink to 51 in 2014. As of 2014, the NHTSA had yet to fulfill a recommendation from an October 2011 report that asked it to evaluate its workforce to determine the most effective size and mix of staff in its investigative office ("Regulator Slow to Respond to Deadly Vehicle Defects" by Hilary Stout, Danielle Ivory, and Rebecca R. Ruiz, *New York Times*, September 14, 2014).

collect and report more information about possible defects, the regulator assumed that it could afford to be less proactive without compromising safety. A second related possibility is that the volume of information being produced was simply too much for the regulator to cope with. However, with technological improvements reducing the risk of fatalities, defects investigation could have become a lower priority over time, and the periods before and after the passage of the TREAD Act reflect this induced time trend in proactivity. For our purposes, though, the precise origin of regulatory slack is not especially important.

5.4.1 The TREAD Act and Regulatory Proactivity

In this subsection, we present three types of evidence suggesting that the regulatory environment changed after the TREAD Act became law.

In Figure 4, we provide some evidence broadly consistent with our notion that regulatory proactivity was lower and information quality was higher in the decade after enactment of the TREAD Act compared with the decade before. When the manufacturers have better information and the regulator is less proactive in initiating recalls, we expect the fraction of regulator-initiated recalls to total recalls to be lower. Panel A shows the ratio of recalls that were initiated by NHTSA to all recalls for each year from 1990 to 2008, and Panel B compares the annual average fraction of recalls that were initiated by NHTSA in the decade prior to the TREAD Act with that in the post–TREAD period up to 2008. The results are for the sample of recalls that are above the 50th percentile in terms of *Ratio* (number of affected units in a recall file divided by the number of employees at the beginning of the year) and that occurred within less than eight hundred days from the beginning of the manufacturing date. In Panel B, the average for the pre–TREAD years is 9.6%, and that for the post–TREAD period is about 6.9%, showing a 30%

decline. Moreover, in four of the years in the 1990s, the ratio exceeds 12%, but it does not reach that level for any of the years in the post–TREAD period.

[Insert Figure 4 near here]

As recently as in 2013, NHTSA was ostensibly bowing to pressure from vehicle manufacturers and agreeing to their demands for scaling down government-initiated recalls. The *New York Times* provides the following account of Chrysler's recall of Jeep Grand Cherokees and Jeep Liberties:

> In June 2013 the agency asked Chrysler to conduct a recall of about 2.7 million Jeep Grand Cherokees and Jeep Liberties because of the gas tank problem. If the automaker did not comply, the agency said, it would publish a public notice describing the defects, its investigation into the matter and the scheduling of a public meeting. After the public meeting, N.H.T.S.A. could have legally forced a recall.
>
> But the agency struck a deal with Chrysler instead.
>
> After first refusing to recall the vehicles, Chrysler's chief executive, Sergio Marchionne, spoke with David L. Strickland, who led the agency at the time, and agreed to recall 1.6 million vehicles, according to a person briefed on the conversation. They agreed to install a trailer hitch that would offer more protection in the event of rear-end accidents. It also would be far less costly to Chrysler than more extensive remedies.
>
> As for the remaining 1.1 million vehicles, Chrysler said it would send a notice to dealers, instead of a conducting a recall, which is a far less serious approach to a safety issue. The agency—which looked into the issue only after an outside advocacy group, the Center for Auto Safety, made a formal request—agreed to Mr. Marchionne's demand that it stop describing the vehicles as defective.

In Figure 5, we plot the fraction of investigations of alleged defects initiated by NHTSA each year that lead to recalls. Panel A shows that the fraction of recalls of all sizes increases after the TREAD Act, following the opening of an investigation. However, Panel B shows a contrasting picture. While the fraction of small recalls subsequent to investigations increases, the fraction of large recalls declines sharply after the TREAD Act. This is consistent with the notion that, post-2000, vehicle manufacturers seem to have more leverage with the regulator.

[Insert Figure 5 near here]

Finally, in Figure 6, we plot the average duration of investigations. by investigation year. There is a sharp drop in the duration after the year 2000. While this is consistent with a more efficient administration, in conjunction with the evidence presented in Figure 6, a more likely explanation is that the investigation was typically less thorough, and when it did result in a recall, the recall was of a smaller scale than was the case in the 1990s.

[Insert Figure 6 near here]

5.4.2 The TREAD Act, Maturing Debt, and Recall Delay

In this subsection, we examine how financial structure affects the recall incentives of vehicle manufacturers. Because most recalls happen within two years of the start of manufacturing, we focus on debt maturing by the end of the year in which manufacturing begins. We do not consider short-term debt in our analysis because short-term debt can be issued (or not issued) after a firm learns about a possible defect and is this clearly endogenous to the recall decision. We control for long-term debt in our regressions but do not have any specific hypotheses about how long-term debt affects recall timing. Our regression sample for recall timing tests is restricted to large recalls (the sample in Panel B, Table 2) that occur within eight hundred days of the beginning of manufacturing. (However, our results are robust to alternative truncations such one thousand days or 1,200 days.)

We exclude recalls that occur much later for three reasons. First, our interest is to see how previously issued debt maturing in the current manufacturing year affects recall timing. Recalls that occur much later are unlikely to be affected by the need for external finance to repay maturing debt. Second, especially in light of the recent spate of large-scale recalls by GM for problems that were known a decade before, a right-truncation issue clearly emerges if we do not restrict the time to recall. Finally, our focus here is to understand firms' incentives to initiate recalls when they have early signals about potential problems. Recalls that occur long after the beginning of manufacturing could reflect problems that were revealed only after debt maturing by the end of the year that manufacturing begins is repaid.

We test whether the level of previously issued long-term debt due to mature by the end of the fiscal year in which manufacturing begins affects the timing of recall. To do so, we arbitrarily choose a cutoff, such as a particular number of days before the fiscal year-end, and examine whether a recall is more likely to occur after this cutoff if a firm has more previously issued debt maturing within the year in which manufacturing begins.

The logic is as follows. As implied by our model outlined in Subsection 3.2, a higher level of maturing debt could lead to either later or earlier recalls, depending on the nature of the regulatory environment. For example, a firm with a signal about a potential defect might choose to wait to issue a recall until less costly information accumulates in the form of consumer complaints or feedback from dealers or the regulator. Higher levels of maturing debt exacerbates the incentive to delay, as recalling is costly immediately prior to the maturity of the debt or when financing is to be arranged to repay the debt. A higher level of maturing debt will not only increase costs, but also make it more difficult to raise the required funding quickly, leading to delayed recalls. If the regulator is not very proactive, the firm has some leeway to delay recalls when the advantage of doing so outweighs the benefit. Thus, in a less proactive regulatory regime, for any arbitrary cutoff date within the manufacturing year, the likelihood of a recall before that cutoff will decrease in the amount of previously issued debt that is due to mature in that year.

In a more proactive regulatory regime, a firm with an early signal and high levels of debt maturing may face a recall initiated by the regulator when the debt is about to mature, which could be very costly. As a result, such a firm might recall quickly when it has maturing debt even with relatively imprecise information – an incentive that would be stronger the higher the level of maturing debt. However, if the signal is received very close to maturity, especially if the signal quality is good, the firm might delay recall when, in the absence of the debt, it would have recalled. This potentially makes the implications for the effects of debt on recall timing ambiguous when the regulator is sufficiently proactive.

For our test, we construct, as our dependent variable, an indicator that takes a value of one if a recall (either manufacturer- or government-initiated) occurs after the cutoff, which is one hundred days in Table 4. Our results are robust to a number of alternative cutoffs such as 70 days, 80 days, or 120 days. The indicator takes a value of zero if a manufacturer-initiated recall occurs before the cutoff.[30] Thus, we exclude government-initiated recalls before the cutoff, because these do not indicate whether the firm intended to delay beyond the cutoff.[31] We control for long-term debt, cash holdings, inventory, profitability, sales growth, firm size, and logarithm of the number of models in the recall campaign.

[Insert Table 4 near here]

Importantly, we control for the time between the beginning of manufacturing and the end of the fiscal year. (Because the cutoff is fixed, this is equivalent to controlling for the time between beginning of manufacturing and the cutoff.) The variable *Interval* is likely to be

[30] We exclude recall files when the earliest date for the commencement of manufacturing for any affected model is later than the cutoff.
[31] However, our results continue to hold if the relatively small number of early government-initiated recalls are included.

negatively related to the likelihood of a late recall because the earlier the manufacturing is initiated, the more likely that the firm will learn about a potential defect before the cutoff.

We introduce an indicator variable *TREAD*, which takes the value of one for manufacturing year in the post–TREAD Act period (after November 2000) and zero otherwise.[32] We interact the level of maturing debt with this indicator variable to capture the effect of regulatory proactivity on strategic recall timing.

Figure 7 presents univariate results. Recalls initiated by manufacturers are classified as belonging to either the high maturing debt (HMD) subsample or the low maturing debt (LMD) subsample depending on whether the firm-year is characterized by maturing debt levels that are above or below the sample median. For each recall above the *Rate* ≥ 75th percentile cutoff in the HMD subsample, we find another recall in the LMD subsample initiated by the same manufacturer in the same calendar month (but, necessarily, a different year). If multiple recalls match these two criteria in the LMD subsample, we pick the one for which the fiscal year is the closest to the initial recall from the HML subsample. Figure 7 shows that, in the pre–TREAD period, the fraction of early recalls in the HML subsample is 22%, compared with 16% for the LMD subsample. However, in the post–TREAD period, this pattern is reversed. The fraction of early recalls for the HMD subsample is 16%, but it is 26% for the LMD subsample.

[Insert Figure 7 near here]

In Table 4, we report three sets of results. Column 1 has results from a probit regression, and Column 2 presents the key marginal effects. Because Stata's "dprobit" command does not generate the correct marginal effects for interaction terms, we report the corrected marginal effects in curly brackets in Column 2. Columns 3 and 4 contain results for the linear probability

[32] Recall observations for which manufacturing began prior to November 1, 2000, but recall occurred after that date are not in the sample.

model. We include firm fixed effects for the model corresponding to Column 4. Inclusion of firm fixed effects mitigates some endogeneity concerns. For example, it could be the case that firms with poor product quality typically recall later and also have higher levels of long-term debt, which translates to higher amounts of maturing debt in any given year. Because multiple recalls by the same firm in the same year but with different recall dates is common in our sample, we cluster standard errors at the firm-year level. The regressions control for the state of incorporation for U.S.-listed firms and the country for non-U.S.-listed firms. In addition, we include fixed effects for the component affected and year fixed effects.[33]

The results indicate that the TREAD Act has a significant negative effect on the likelihood of late recalls. The marginal effect is large, indicating that the probability of a late recall decreases by between 21 percent and 32 percent (for the three sets of regressions) after the TREAD Act relative to the base period. Higher levels of maturing debt have opposite effects on the likelihood of early recalls in the two periods, consistent with our hypothesis. The interaction of maturing debt and the *TREAD* dummy is positive, and the effect of maturing debt itself is negative in the base period. The economic magnitudes of the marginal effects are as follows. In the pre–TREAD period, a one standard deviation (5%) increase in the level of maturing debt reduces the likelihood of a late recall by about 18%. This is a substantial effect given that the mean frequency of late recalls in the sample is 78%. In the post–TREAD period, a one standard deviation increase in maturing debt increases the likelihood of a late recall by about 11% [(5.88 - 3.65) * 5% = 11%].

5.4.3 The Sample of Serious Complaints

[33] More than 90 percent of the recalls in our sample are recalls of cars. The rest are trucks, trailers, coaches, and motorcycles. We get very similar results to those reported here if we restrict ourselves to car recalls only.

Our arguments motivating the tests reported so far have been predicated on the assumption that the distribution of informative signals received by manufacturers about likely safety issues during the period from commencement of manufacturing to the date debt is due is not affected by the level of maturing debt. However, those with higher levels of maturing debt systematically could receive signals later than those with lower levels of maturing debt. One reason that this could happen is as follows. Suppose, as seems plausible, that the generation of signals observed by customers or dealers is accelerated when the vehicle sales reach a certain threshold. Firms with higher levels of maturing debt could then have an incentive to delay the introduction of new models, which affects the speed with which signals are generated, until financing becomes available to repay debt. While we control for the manufacturing date in our regressions via the variable *Interval*, we do not observe the launch date, and thus we cannot rule out this possibility. [34]

Moreover, it could be argued that the pre–TREAD and post–TREAD periods differ not only in the quality of the signal, but also in terms of how soon a signal of comparable quality is available. For example, suppose signals arrive earlier in the post–TREAD period when information quality improves. While we measure delay in terms of the time that elapses between the start of manufacturing and the recall, an alternative consideration would be to measure it by the time that passes from the initial signal to the recall event, which we do not observe. Could our results be attributable to mis-measuring recall delay? We think this is unlikely. While mis-measurement could explain why firms recall earlier in the post–TREAD period, it does not in itself explain why higher levels of maturing debt lead to greater delay.

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[34] A similar concern is that higher amounts of maturing debt may affect the effort that goes into generating an informative signal.

Nonetheless, to deal with these issues, we consider a sample for which a type of signal is generated only after a vehicle is launched, and this signal is important enough that the manufacturer is aware that a problem could exist. This sample of recalls is associated with serious consumer complaints about vehicle safety. The NHTSA maintains a record of all safety-related defect complaints it receives since January 1, 1995. The Office of Defects Investigation (ODI), an office within the NHTSA, conducts investigations into alleged defects and administers safety recalls based on the number of complaints filed for child seats, tires, equipment, and vehicles. Each complaint file contains information relevant to our study, including the name of manufacturer, the make and model of the vehicle or equipment, a description of the defective component, the date that the complaint was received by NHTSA, the number of injuries or fatalities in each accident reported, and whether or not a vehicle was involved in a fire or a crash. We define any complain about a vehicle being involved in a crash or a fire or associated with injuries or fatalities as a serious complaint.

Table 5 describes the serious complaint sample. We report results for the overall sample, as the sample consists mostly of relatively large recalls. (In terms of *Rate*, the 75th percentile value of the overall sample is at the 18th percentile for the compliant sample.) The mean number of units affected by the recalls is larger than that reported in Panel B of Table 2. *Recall Timing* indicates the percentage of recalls that are issued after one hundred days from the end of the fiscal year in which the complaint is received. Seventy percent of the recalls are issued later than this cutoff. Not surprisingly, the percentage of government-initiated recalls is considerably higher at 22%, compared with 12% for the sample in Panel B of Table 2. Among the firm characteristics, the firms involved in these recalls have somewhat higher debt ratios (for both maturing and long-term debt). Maturing debt is previously issued debt that would have matured in the year that the first serious complaint is received.

[Insert Table 5 near here]

We define an early recall as a manufacturer-initiated recall that occurs within one hundred days of the end of the fiscal year in which the first serious complain associated with a recall was received. If the recall (either manufacturer- or government-initiated) occurs after this cutoff, it is considered late. Our dependent variable is a dummy variable that takes a value of one if the recall is late and zero if it is early. We include the same set of control variables as in Table 4, except *Interval*, which is now the length of time between the date of the first serious complaint and the end of the fiscal year. Table 6 reports regression results analogous to those in Table 4.

[Insert Table 6 near here]

Consistent with our earlier results, the likelihood of an early recall increases after the TREAD Act became law. The marginal effect is 51 percentage points for the probit specification in Column 1 and 41% (23%) for the linear probability specification without (with) firm fixed effects. A higher level of maturing debt increases the likelihood of an early recall in the pre–TREAD period but decreases for the post–TREAD period. The net effect of a one standard deviation increase in the level of maturing debt after enactment of the TREAD Act is a 24 percentage point increase in the probability of a late recall for the probit specification, compared with an unconditional probability of 70% of a late recall for this sample. For the linear probability models, the net effect of a one standard deviation increase in maturing debt is to increase the probability of a late recall by about 16%. However, there is no net effect when firm fixed effects are included in the linear probability specification.

5.5 Cross-sectional Proxies for Regulatory Monitoring and Recall Timing

While it is difficult to see how, absent a strategic timing motive related to the cost of external finance, the TREAD Act or other time trends in vehicle safety or the information content of signals could have opposite effects on recall timing for firms with low versus high levels of maturing debt, to alleviate related concerns we explore the effects of cross-sectional variations in NHTSA proactivity. To do so, we use the presence of a NHTSA regional office in a state as an instrument for proactivity.[35] Our expectation is that NHTSA will be more proactive vis-à-vis serious complaints that originate in states where it has a regional office. We further argue that while it is less likely to be proactive in a state if it does not have a regional office, this would be less likely to be the case if the complaint originates in a city within such a state with high population density or high population. As a result, higher levels of maturing debt would be associated with delayed recalls in states without regional offices, with the former effect being attenuated in cities with high population density (population). In Table 7, we report results based on the complaint sample. Again, we focus on the location of the first complaint. All regressions include year dummies, as well as dummies for the state of incorporation and the defective component. We create a dummy variable for population density in a city being above the 75th percentile of all cities where the first complaint occurs. Results for a corresponding dummy for city population are similar and are not reported.[36] The results show that higher levels of maturing debt lead to later recalls in states where the NHTSA does not have a regional office. (The effect is marginally significant on an ordinary least squares regression when firm fixed effects are added.) But, in states where a regional office is present, the effect either is insignificant or has

[35] NHTSA has regional offices in ten states: California, Colorado, Georgia, Illinois, Maryland, Massachusetts, Missouri, New York, Texas, and Washington.

[36] Unfortunately, with this specification, the correct probit marginal effect for the interaction term in the probit model cannot be computed using the "inteff" command in Stata. The probit estimation also does not converge when we restrict attention to recalls that occur within eight hundred days from the beginning of manufacturing for the first column in Table 7, so we report results for both columns for recalls that occur within 1,500 days.

the opposite sign. The effect of higher levels of maturing debt in delaying recalls in cities located in states without a regional office is attenuated, however, if the city has high population density.

6. Conclusion

In this paper, we study vehicle manufacturers' incentives to voluntarily announce product recalls. We ask how such incentives are affected by the nature of regulation, as well as the manufacturers' financial structure. The passage of the TREAD Act in the fall of 2000 allows us to examine how the regulatory regime affects recall incentives and how financial structure interacts with the regulatory regime to shape such incentives.

Restricting attention to recalls of vehicles that have a high rate of sales per day and are potentially costly to recall, we find that, after enactment of the TREAD Act, firms are less likely to delay recalls beyond one hundred days (alternatively, 80, 120, or zero days) from the end of the fiscal year in which the manufacturing of the vehicle commences, compared with the previous decade (i.e., the 1990s). However, they are more likely to delay recalls if they have higher levels of debt that is due to mature within the year in which manufacturing begins after the TREAD Act went into effect. The opposite is the case in the previous decade. While the result that firms recall earlier after the TREAD act became law is consistent with a variety of explanations including more informative signals about product defects with manufacturers, the results on the effect of maturing debt on recall timing suggest a strategic motive related to how recalls impact the cost of external finance. In particular, the latter results are consistent with the notion that NTHSA became less proactive after the passage of the TREAD Act, which enabled manufacturers to delay recalls, without regulatory pressure, when that served their interest. Consistently, we find that if the first serious complaint about a model occurs in a state in which NHTSA does not have a regional office (suggesting less regulatory attention), firms with higher levels of maturing debt are more likely to delay recalls. This effect is weakened if the city in question has higher population density (suggesting more regulatory attention within the state).

Our results have implications for the general question of how financial structure affects the incentives of firms to disclose information and, more specifically, for the recent debate of “who knew what and when” in several high-profile recalls. For GM’s ignition switch problem, the Valukas report completely absolved top management of any knowledge of the defects, noting that the information about the problem did not reach their level of the company until January 2014. However, our results suggest that this is unlikely to be typical. Considerations such as the possible impact of recalls on the cost of finance are top management–level issues, and if recalls are being timed to mitigate the financial impact of recalls, it is very likely that the information flow within the manufacturing firms about the potential vehicle problems typically does reach the upper levels of management.

Table A1. Recall Time Trends

This table presents information on the frequency of recalls by vehicle manufacturers and parts suppliers from January 1966 to July 2010. The numbers shown are aggregated over five-year periods. Number of manufacturer- or supplier-initiated recalls is the number of manufacturer- or supplier-initiated recall reports submitted to the National Highway Traffic Safety Administration (NHTSA). Number of units is the estimated number of defective products in each recall file. Manufacturer- or supplier-initiated recalls are recalls initiated by vehicle manufacturer or parts supplier firms, not by NHTSA.

Sample period	Number of recalls (A)	Number of manufacturer- or supplier-initiated recalls (B)	B/A	Number of units (C)	Number of units in manufacturer- or supplier-initiated recalls (D)	D/E
1966–1970	57	54	94.74%	714,175	649,738	90.98%
1971–1975	535	427	79.81%	16,693,361	7,401,713	44.34%
1976–1980	726	565	77.82%	30,016,290	9,837,133	32.77%
1981–1985	886	731	82.51%	55,574,410	15,566,131	28.01%
1986–1990	1,160	923	79.57%	54,276,317	25,670,995	47.30%
1991–1995	1,262	895	70.92%	65,324,370	18,862,409	28.87%
1996–2000	1,902	1,467	77.13%	106,278,783	37,576,179	35.36%
2001–2005	2,534	1,981	78.18%	115,480,899	51,033,647	44.19%
2006–2010	2,368	1,834	77.45%	55,865,862	28,632,182	51.25%
Total	11,430	8,877	77.66%	500,224,467	195,230,127	39.03%

Table A2. Recall Distribution over Component Types

This table presents the recall distribution over component types initiated by vehicle manufactures and parts suppliers. Number of recalls is the number of recall reports submitted to the National Highway Traffic Safety Administration. Number of units is the estimated number of defective products in each recall file.

Component name	Number of recalls	Percentage of number of total recalls	Number of units	Percentage of total number of units
Service brake	1,502	13.14	31,138,609	6.22
Equipment	1,296	11.34	19,599,884	3.92
Fuel system	954	8.35	53,425,898	10.68
Steering	912	7.98	18,470,547	3.69
Suspension	787	6.89	27,510,651	5.50
Electrical system	680	5.95	31,489,504	6.30
Structure	526	4.60	27,889,857	5.58
Power train	520	4.55	45,541,521	9.10
Engine and engine cooling	516	4.51	13,986,920	2.80
Seat belts	472	4.13	38,729,203	7.74
Exterior lighting	399	3.49	24,694,107	4.94
Tires	382	3.34	17,340,720	3.47
Vehicle speed control	377	3.30	24,591,672	4.92
Visibility	357	3.12	20,720,416	4.14
Wheels	352	3.08	4,326,322	0.86
Seats	292	2.55	12,752,129	2.55
Air bags	214	1.87	14,141,410	2.83
Trailer hitches	205	1.79	2,305,066	0.46
Child seat	174	1.52	51,163,788	10.23
Latches	154	1.35	13,713,391	2.74
Parking brake	153	1.34	2,928,945	0.59
Unknown or other	155	1.36	2,449,008	0.49
Interior lighting	37	0.32	753,714	0.15
Communications	8	0.07	487,650	0.10
Electronic stability control	6	0.05	73,535	0.01
Total	11,430	100.00	500,224,467	100.00

Table A3. Sample Construction

Criteria	Number
Entries from January 1966 to July 2010 (vehicle manufacturers and parts suppliers)	
Total	84,580
Have non-missing date for the start of manufacturing	60,303
Recall files with distinct recall campaign numbers	
Total	11,521
Have non-missing date at which a recall report is filed	11,512
Have non-missing number of units affected in each recall file	11,499
Have recall files submitted later than the date at which manufacturing begins	11,492
Have no recall duplicates	11,430
Are public firms or a subsidiary of public firms	5,473
Satisfy criteria for inclusion in the regressions	3,160
Are vehicle manufacturers	2,843

Table A4. Maturing Debt, Big Recalls, and the Probability of Credit Ratings Downgrades

This table presents the estimates of the interaction between maturing debt and large recalls on the probability of credit ratings downgrades for public vehicle manufacturers. The dependent variable is a dummy variable defined as one if a firm's Standard and Poor's credit rating for long-term debt is at least one notch lower at the end of the recall year than the year before and zero otherwise. Column 1 presents probit regression results. Column 2 presents dprobit coefficients for key independent variables. The mean of correct marginal effect of a change in two interacted variables for probit model is presented in curly brackets. Column 3 and 4 present linear probability regression results with and without firm fixed effects, respectively. *H1* is a dummy variable defined as one if maturing debt is above median in the sample with a non-missing credit rating and zero otherwise. *Big* is a dummy variable defined as one if the aggregated number of units scaled by total number of employees is above median in the sample in which recall occurs and zero otherwise. Ln (*# of Employees*) is the logarithm of total number of employees. Ln (*Score*) is the logarithm of integer value of the credit rating in the year before the recall. *Incorporation* is an indicator variable for the state (country) where a U.S. (an international) firm is incorporated. *Year* is the fiscal year. All financial variables are as of the beginning of the fiscal year. Table 2 contains definitions of other variables. Standard errors in parentheses are clustered at the firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. OLS = ordinary least squares.

	(1)	(2)	(3)	(4)
Variable	Probit	Probit Marginal Effects	OLS	OLS
H1	-0.44	-0.12	-0.09	-0.07
	(0.37)		(0.08)	(0.08)
*H1 * Big*	1.52**	0.48	0.22**	0.23*
	(0.67)	{0.30}	(0.09)	(0.11)
Big	-0.93	-0.23	-0.08	-0.07
	(0.60)		(0.08)	(0.08)
Ln (*# of Employees*)	0.62*		0.11	0.31
	(0.37)		(0.07)	(0.18)
Long-term Debt	3.14*		0.74*	1.17***
	(1.64)		(0.40)	(0.40)
EBIT	-19.45***		-4.17***	-3.91***
	(4.37)		(0.66)	(0.82)
Sales Growth	0.43		0.11	0.03
	(0.99)		(0.15)	(0.16)
Cash	1.76		0.34	0.72
	(2.69)		(0.52)	(0.64)
Inventory	-0.81		-0.11	-1.00
	(1.72)		(0.32)	(0.70)
Ln (*Total Asset*)	-0.49		-0.09	-0.18
	(0.31)		(0.06)	(0.13)
Ln (*Score*)	10.89**		2.26**	5.99***
	(5.09)		(1.06)	(1.12)
Intercept	-49.87**		-10.25**	-28.11***
	(22.68)		(4.84)	(5.61)
Incorporation	Yes		Yes	Yes
Component	Yes		Yes	Yes
Year	Yes		Yes	Yes
Firm effects	No		No	Yes
N	239		296	296
Pseudo R^2	0.30			
Adjusted R^2			0.22	0.25

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Table 1. Recall Distribution over Stock Exchanges

This table presents the recall distribution for public vehicle manufacturers over stock exchanges. Number of manufacturers is the number of public vehicle manufacturers. Number of recalls is the number of recall reports submitted. Number of units is the estimated number of defective products in each recall file.

Stock exchange	Number of manufacturers	Percentage of total number of manufacturers	Number of recalls	Percentage of total number of recalls	Number of units	Percentage of total number of units
NYSE	23	50.00	1,983	69.75	75,849,864	91.25
Tokyo Stock Exchange	9	19.57	226	7.95	5,186,967	6.24
Frankfurt Stock Exchange	5	10.87	279	9.81	1,070,084	1.29
OTC	4	8.70	160	5.63	129,465	0.16
NASDAQ	2	4.35	140	4.92	273,059	0.33
Korea Stock Exchange	1	2.17	33	1.16	561,996	0.68
Milan Stock Exchange	1	2.17	20	0.70	48,627	0.06
Toronto Stock Exchange	1	2.17	2	0.07	46	0.00
Total	46	100.00	2,843	100.00	83,120,108	100.00

Table 2. Sample Summary Statistics

This table presents summary statistics on the sample of public vehicle manufacturers that are involved in recall initiations. *Rate* is the estimated number of defective products in a recall file scaled by *Days of Delay*. *Days of Delay* is the number of days from the beginning of manufacturing to the date the recall report is submitted to the National Highway Traffic Safety Administration (NHTSA). Panel A presents summary statistics on the entire sample. Panel B presents summary statistics on the subsample in which *Rate* is above the 75th percentile. *Recall Timing* is a dummy variable defined as one if a firm files a recall report later than one hundred days prior to the fiscal end of the year that manufacturing begins and is zero if a recall is initiated by the manufacture and filed before the cutoff date. *GovtIN* is a dummy variable defined as one if a recall is initiated by the NHTSA, not by manufacturers, and zero otherwise. *# of Units* is the estimated number (in thousands) of defective products as reported in each recall file. *# of Models* is the number of vehicle model types affected in each recall. *Interval* is the number of days from the beginning of manufacturing to the fiscal end of the manufacturing year. *Maturing Debt* is the long-term debt due within one year. *Long-term Debt* is the debt due after one year. *EBIT* is earnings before interest and taxes. *Sales Growth* is the growth rate of net sales. *Cash* is cash and short-term investments. *Inventory* is total inventory. *Total Asset* is firm total asset (in billions) in U.S. dollars. All financial characteristics are as of the year before the manufacturing year and, except for sales growth, are scaled by *Total Asset*.

Panel A: Entire sample

Variable	*N*	Mean	Standard deviation	25th percentile	50th percentile	75th percentile
Recall characteristics						
Recall Timing	2,830	0.76	0.43	1	1	1
Days of Delay	2,843	301.16	208.6	122	253	444
GovtIn	2,843	0.07	0.25	0	0	0
# of Units	2,843	29.24	137.64	0.21	1.60	12.3
Rate	2,843	87.80	337.95	1.06	7.98	56.16
# of Models	2,843	3.55	4.57	1	2	4
Interval	2,843	232.38	77.13	152	226	303
Financial characteristics						
Maturing Debt	2,843	0.05	0.05	0.01	0.05	0.07
Long-term Debt	2,843	0.17	0.11	0.08	0.17	0.24
EBIT	2,843	0.06	0.07	0.02	0.05	0.09
Sales Growth	2,843	0.08	0.20	-0.02	0.07	0.16
Cash	2,843	0.11	0.07	0.06	0.09	0.14
Inventory	2,843	0.15	0.11	0.06	0.12	0.20
Total Asset	2,843	91.87	115.70	4.39	26.66	180.60

Panel B: *Rate* > 75th percentile

Variable	*N*	Mean	Standard deviation	25th percentile	50th percentile	75th percentile
Recall characteristics						
Recall Timing	787	0.78	0.41	1	1	1
Days of Delay	788	315.72	216.99	128	278	471
GovtIn	788	0.12	0.32	0	0	0
# of Units	788	99.61	248.02	14.84	36.52	88.09
Rate	788	295.46	593.61	73.02	133.61	286.46
# of Models	788	4.21	5.71	1	2	4
Interval	788	229.41	75.81	152	216	298.5
Financial characteristics						
Maturing Debt	788	0.05	0.04	0.01	0.05	0.08
Long-term Debt	788	0.20	0.10	0.13	0.20	0.27
EBIT	788	0.06	0.05	0.02	0.05	0.08
Sales Growth	788	0.08	0.17	-0.01	0.07	0.13
Cash	788	0.10	0.06	0.06	0.08	0.12
Inventory	788	0.12	0.08	0.06	0.09	0.15
Total Asset	788	132.37	125.94	18.10	72.60	237.55

Table 3: Recall Frequency

This table presents information on the frequency of recalls in the sample of public vehicle manufacturers. *Recall Frequency* is the total number of manufacturing years, as a percentage of the number of years a public manufacturer has been listed, in which a recalled product is produced. *# of Recalls/Year* is the average number of recall reports for which manufacturing commenced in the same year. Big Three refers to Ford, General Motors, and Chrysler in the U.S.; Toyota, Honda, and Nissan in Japan; and Daimler, BMW, and Volkswagen in Germany.

Group	*Recall Frequency*				*# of Recalls/Year*		
		Mean	50th percentile	Mean	50th percentile	*N*	Number of recalls
Ford	100%			11.25	10	40	450
GM	100%			15.5	15.5	40	620
Chrysler	100%			7.85	7	20	157
Toyota	88.24%			3.2	3	15	48
Honda	72.97%			3.48	2	27	94
Nissan	94.44%			4.24	4	17	72
Daimler	100%			16.7	13	20	334
BMW	25%			5.75	5.5	4	23
Volkswagen	75%			4.83	4.5	6	29
Big Three		92.88%	100.00%	9.67	7	189	1,827
Non–Big Three		67.94%	73.17%	2.97	2	342	1,016
Full sample		76.82%	74.36%	5.35	3	531	2,843

Table 4. Effect of the TREAD Act on Recall Delay

This table presents estimates of the effect of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act on recall delay and how the act affected the impact of maturing debt on recall timing by public vehicle manufacturers for the sample of recalls with *Rate* ≥ 75%. *Rate* is the estimated number of defective products scaled by *Days of Delay*, as defined in Table 2. The dependent variable is a dummy variable defined as one if a manufacturer- or government-initiated recall occurs later than one hundred days prior to the fiscal end of the manufacturing year and zero if a voluntary recall occurs earlier than the above cutoff. Column 1 presents probit regression results. Column 2 presents dprobit coefficients for key independent variables. The corrected marginal effect of a change in two interacted variables for probit model is presented in curly brackets. Column 3 and 4 present linear probability regression results with and without firm fixed effects, respectively. *TREAD* is a dummy variable defined as one if the defective product recalled is manufactured after November 1, 2000, and zero if the recall occurs before November 1, 2000. Recall observations for which manufacturing began prior to November 1, 2000, but recall occurred after that date are not in the sample. Ln (*# of Models*) is the logarithm of the number of vehicle model types affected in each recall. Ln (*Interval*) is the logarithm of *Interval* as defined in Table 2. *Incorporation* is an indicator variable for the state (country) where a U.S. (an international) firm is incorporated. *Component* is an indicator variable for the type of the defective component. *Year* is the fiscal year. All financial variables are as of the beginning of the manufacturing year. Table 2 contains the definitions of other variables. Standard errors in parentheses are clustered at the firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. OLS = ordinary least squares.

	(1)	(2)	(3)	(4)
Variable	Probit	Probit Marginal Effects	OLS	OLS
Maturing Debt	-15.25*	-3.65	-2.74	-3.90*
	(8.55)		(1.98)	(2.07)
*Maturing Debt * TREAD*	24.89***	5.97	4.52**	5.98**
	(8.87)	{5.88}	(2.13)	(2.37)
TREAD	-1.32**	-0.32	-0.21*	-0.28**
	(0.53)		(0.12)	(0.14)
Long-term Debt	-1.30		-0.23	-0.01
	(1.12)		(0.32)	(0.38)
EBIT	-2.29		-0.45	-0.14
	(3.44)		(0.91)	(0.90)
Sales Growth	1.11**		0.20*	0.20*
	(0.46)		(0.12)	(0.11)
Cash	-1.94		-0.40	-1.07
	(2.06)		(0.53)	(0.79)
Inventory	9.11***		1.61**	1.57
	(3.22)		(0.66)	(1.22)
Ln (*Total Asset*)	-0.20**		-0.04	-0.12
	(0.10)		(0.02)	(0.07)
Ln *(# of Models*)	0.02		0.01	0.01
	(0.09)		(0.02)	(0.02)
Ln (*Interval*)	-1.88***		-0.38***	-0.38***
	(0.31)		(0.05)	(0.05)
Intercept	12.43***		2.35***	4.13***
	(2.18)		(0.44)	(0.93)
Incorporation	Yes		Yes	Yes
Component	Yes		Yes	Yes
Firm effects	No		No	Yes
N	483		515	515
Pseudo R^2	0.21			
Adjusted R^2			0.13	0.13

Table 5. Sample Summary Statistics: Complaint Sample

This table presents summary statistics for the complaint sample of public vehicle manufacturers. *Recall Timing* is a dummy variable defined as one if a firm files a recall report later than one hundred days prior to the fiscal end of the year in which customers file the first serious complaint to the National Highway Traffic Safety Administration (NHTSA) and zero otherwise. A serious complaint is defined as a complaint filed by customers that either claims a vehicle is involved in a crash or fire or reports the number of fatalities or injuries. *Days of Delay* is the number of days from the date at which NHTSA receives the first serious complaint to the date the recall report is submitted. *GovtIN* is a dummy variable defined as one if a recall is initiated by NHTSA, not by manufacturers, and zero otherwise. *# of Units* is the estimated number (in thousands) of defective products as reported in each recall file. *# of Models* is the number of vehicle model types affected in each recall. *Interval* is the number of days from the date at which NHTSA receives the first serious complaint to the fiscal end of the recall claims that the year. *Maturing Debt* is the long-term debt due within one year as of the beginning of the first complain year. *Long-term Debt* is the debt due after one year. *EBIT* is earnings before interest and taxes. *Sales Growth* is the growth rate of net sales. *Cash* is cash and short-term investments. *Inventory* is total inventory. *Total Asset* is firm total asset (in billions) in U.S. dollars. All financial characteristics are as of the year before the year in which customers file the first serious complaint and, except for sales growth, are scaled by *Total Asset*.

Variable	*N*	Mean	Standard deviation	25th percentile	50th percentile	75th percentile
Recall characteristics						
Recall Timing	314	0.70	0.46	0	1	1
Days of Delay	331	277.75	216.55	77	239	428
GovtIN	331	0.22	0.42	0	0	0
# of Units	331	122.88	310.88	8.32	36	121
Rate	331	1044.10	5516.01	37.71	197.39	614.42
# of Models	331	4.46	5.91	2	2	4
Interval	331	233	74.25	161	240	292
Financial characteristics						
Maturing Debt	331	0.08	0.05	0.05	0.07	0.09
Long-term Debt	331	0.23	0.08	0.17	0.22	0.29
EBIT	331	0.05	0.03	0.02	0.05	0.07
Sales Growth	331	0.10	0.25	0.00	0.07	0.14
Cash	331	0.10	0.04	0.06	0.09	0.12
Inventory	331	0.08	0.05	0.03	0.08	0.11
Total Asset	331	128.61	120.80	4.77	90.05	243.28

Table 6. Effect of the TREAD Act on Recall Delay: Complaint Sample

This table presents estimates of the effect of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act on recall delay and how the act affected the impact of maturing debt on recall timing by public vehicle manufacturers for the complaint sample of recalls. The dependent variable is a dummy variable defined as one if a manufacturer- or government-initiated recall occurs later than a cutoff prior to the fiscal end of the year in which customers file the first serious complaint to the National Highway Traffic Safety Administration and zero if a manufacturer-initiated recall occurs earlier than that cutoff. A serious complaint is defined as a complaint filed by customers that either claims a vehicle is involved in a crash or fire, or reports the number of fatalities or injuries. Regression results are reported when one hundred days is used as the cutoff. Complaints occurring after the cutoff are excluded. Column 1 presents probit regression results. Column 2 presents dprobit coefficients for key independent variables. The corrected marginal effect of a change in two interacted variables for probit model is presented in curly brackets. Column 3 and 4 present linear probability regression results with and without firm fixed effects, respectively. *TREAD* is a dummy variable defined as one if the defective product recalled is manufactured after November 1, 2000, and zero if the recall occurs before November 1, 2000. Recall observations for which manufacturing began prior to November 1, 2000, but recall occurred after that date are not in the sample. Ln (*Interval*) is the logarithm of *Interval* as defined in Table 5. *Incorporation* is an indicator variable for the state (country) where a U.S. (an international) firm is incorporated. *Component* is an indicator variable for the type of the defective component. *Year* is the fiscal year. All financial variables are as of the beginning of the manufacturing year. Table 5 contains definitions of other variables. Standard errors in parentheses are clustered at the firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. OLS = ordinary least squares.

	(1)	(2)	(3)	(4)
Variable	Probit	Probit Marginal Effects	OLS	OLS
Maturing Debt	-28.08***	-9.15	-6.69**	-7.39***
	(9.38)		(2.56)	(2.59)
*Maturing Debt * TREAD*	36.85***	12.01	8.50***	7.43**
	(9.84)	{8.30}	(2.55)	(2.87)
TREAD	-1.87***	-0.52	-0.41***	-0.23
	(0.60)		(0.15)	(0.22)
Long-term Debt	-7.46**		-1.44*	-1.98*
	(3.14)		(0.78)	(1.09)
EBIT	-24.17***		-4.76***	-4.39**
	(5.91)		(1.39)	(1.80)
Sales Growth	1.36***		0.30*	0.26*
	(0.51)		(0.16)	(0.15)
Cash	-6.17*		-1.23	-2.31**
	(3.31)		(0.92)	(1.05)
Inventory	-3.91		-0.99	0.35
	(3.07)		(0.86)	(1.97)
Ln (*Total Asset*)	-0.06		-0.01	-0.19*
	(0.10)		(0.03)	(0.11)
Ln *(# of Models*)	0.56***		0.12***	0.14***
	(0.15)		(0.04)	(0.04)
Ln (*Interval*)	-1.66***		-0.40***	-0.36***
	(0.32)		(0.09)	(0.09)
Intercept	14.01***		3.62***	5.44***
	(2.65)		(0.61)	(1.29)
Incorporation	Yes		Yes	Yes
Component	Yes		Yes	Yes
Firm effects	No		No	Yes
N	274		282	282
Pseudo R^2	0.29			
Adjusted R^2			0.19	0.23

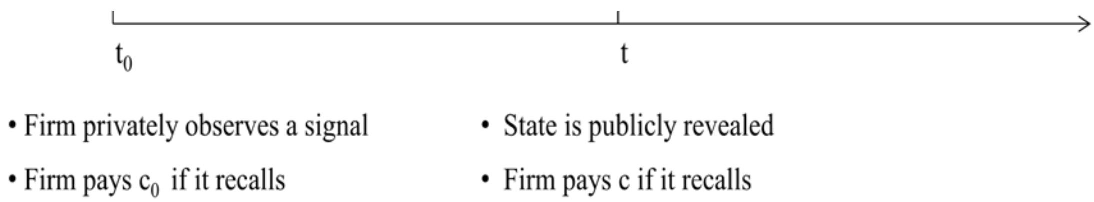
Table 7. Effect of Regulatory Monitoring on Recall Delay: Complaint Sample

This table presents estimates of the effect of maturing debt on recall timing by public vehicle manufacturers and how regulatory monitoring affects recall timing in the presence of maturing debt. The dependent variable is a dummy variable defined as one if a manufacturer- or government-initiated recall occurs later than a cutoff prior to the fiscal end of the year in which customers file the first serious complaint to the National Highway Traffic Safety Administration (NHTSA) and zero if a manufacturer-initiated recall occurs earlier than that cutoff. A serious complaint is defined as a complaint filed by customers that either claims the vehicle is involved in a crash or fire or reports the number of fatalities or injuries. *Density75* is a dummy variable defined as one if the population density in a city in which the first serious complaint is filed is above the 75th percentile and zero otherwise. The sample is divided into two subsamples based on whether the first serious complaint is filed in the state where a NHTSA regional office is located. Regression results are reported when one hundred days is used as the cutoff. Complaints occurring after the cutoff are excluded. Columns 1 and 3 present probit regression results. Columns 2 and 4 present marginal effects for key independent variables. Column 5–8 present linear probability regression results with and without firm fixed effects. Ln (*Interval*) is the logarithm of *Interval* as defined in Table 5. *Incorporation* is an indicator variable for the state (country) where a U.S. (an international) firm is incorporated. *Component* is an indicator variable for the type of the defective component. *Year* is the fiscal year. All financial variables are as of the beginning of the manufacturing year. Table 5 contains definitions of other variables. Standard errors in parentheses are clustered at the firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively. OLS = ordinary least squares.

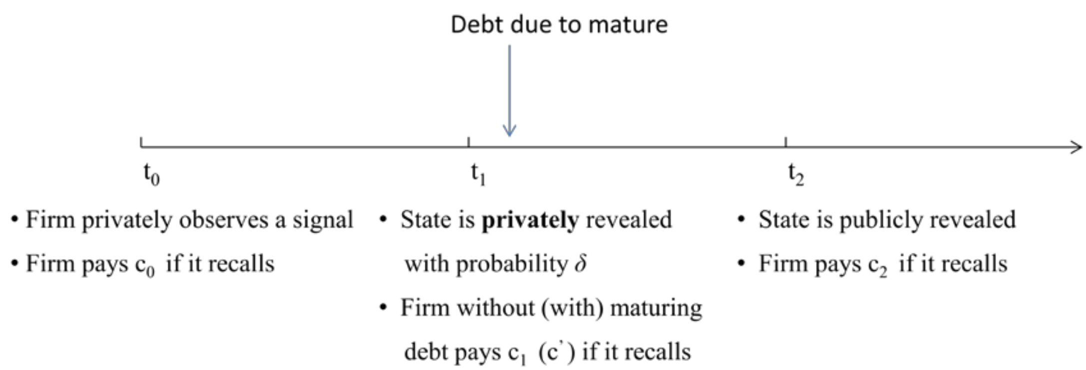
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Probit	Probit Marginal Effects	Probit	Probit Marginal Effects	OLS	OLS	OLS	OLS
Maturing Debt	-29.79***	-0.16	12.71**	3.33	0.11	4.86***	-3.89	3.36
	(8.78)		(5.41)		(2.36)	(1.43)	(5.40)	(2.99)
*Maturing Debt * Density75*	-17.88	-0.10	-12.71	-3.33	-0.06	-2.92	0.55	-3.69*
	(15.94)		(7.77)		(1.54)	(1.98)	(2.32)	(2.08)
Density75	2.12	0.01	0.55	0.12	0.00	0.08	-0.07	0.15
	(1.37)		(0.79)		(0.20)	(0.23)	(0.28)	(0.26)
Long-term Debt	-33.80***		-9.23**		-1.68*	-2.63**	-1.32	-2.37
	(10.24)		(3.99)		(0.96)	(1.27)	(2.43)	(1.52)
EBIT	-52.39***		-21.36**		-3.10	-4.12	-2.29	-2.93
	(16.10)		(9.05)		(2.38)	(2.51)	(4.26)	(2.87)
Sales Growth	-7.29***		2.01***		-0.31	0.43***	-0.25	0.43**
	(1.82)		(0.53)		(0.23)	(0.16)	(0.26)	(0.18)
Cash	11.13		-3.32		-0.84	-0.23	-2.80	0.19
	(12.50)		(4.30)		(2.00)	(1.02)	(2.71)	(1.49)
Inventory	-22.82***		-11.31*		-1.33	-2.41	-2.93	-1.40
	(8.16)		(6.87)		(1.67)	(1.78)	(4.11)	(2.45)
Ln (*Total Asset*)	0.33*		0.23		0.00	0.10**	-0.21	0.05
	(0.20)		(0.15)		(0.04)	(0.05)	(0.23)	(0.17)
Ln *(# of Models*)	4.66***		0.40**		0.18**	0.06	0.18**	0.07
	(1.08)		(0.17)		(0.08)	(0.05)	(0.09)	(0.06)
Ln (*Interval*)	-5.47***		-1.28***		-0.32*	-0.35***	-0.34	-0.33**
	(1.44)		(0.41)		(0.17)	(0.11)	(0.24)	(0.12)
Intercept	38.92***		9.16***		2.37	3.42***	5.53*	1.75
	(8.01)		(3.87)		(1.48)	(1.16)	(2.90)	(2.33)
Incorporation	Yes		Yes		Yes	Yes	Yes	Yes
Component	Yes		Yes		Yes	Yes	Yes	Yes
Year	Yes		Yes		Yes	Yes	Yes	Yes
Firm	No		No		No	No	Yes	Yes
N	112		203		125	181	125	181
Pseudo R^2	0.63		0.26					
Adjusted R^2					0.22	0.12	0.17	0.09
In regional office	Yes		No		Yes	No	Yes	No

Figure 1. Model Timeline of Events

Panel A: Preliminary Model (Two Dates, No Regulator)



Panel B: Post–TREAD Period (Three Dates, Less Proactive Regulator)



Panel C: Pre–TREAD Period (Three Dates, More Proactive Regulator)

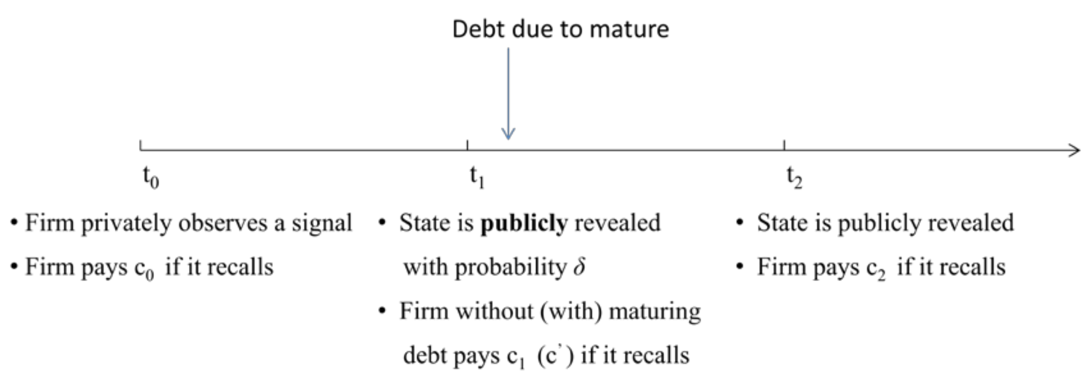
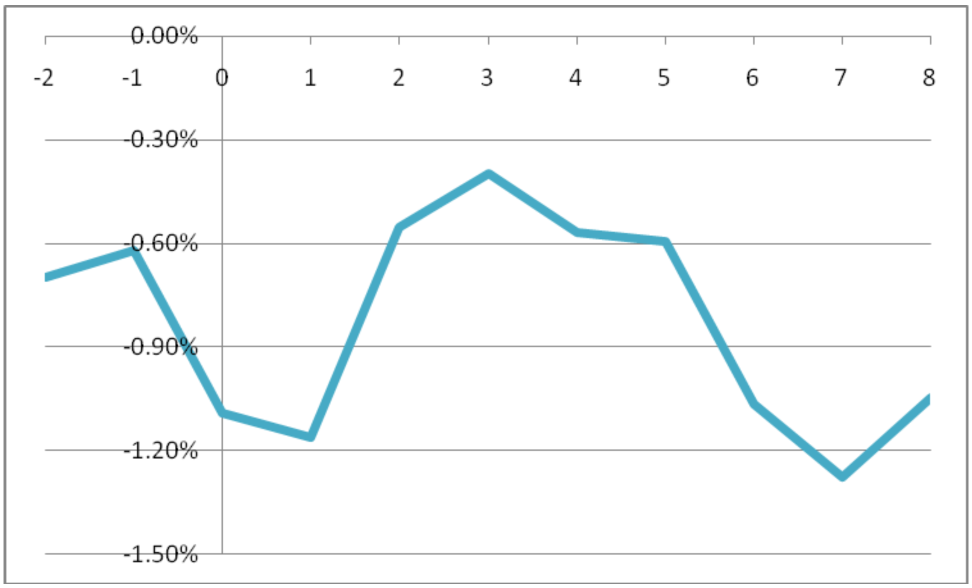


Figure 2. Quarterly Sales Growth around Recall Events

The sample consists of firm-quarter observations for voluntary recalls by public vehicle manufacturers from January 1966 to July 2010. The vertical axis represents quarterly sales growth adjusted by three-digit standard industrial classification industry median. The horizontal axis represents event time, which is zero in the quarter in which recalls occur. *QRatio* is the aggregated number of units affected by the firm's recall in a given quarter scaled by total number of employees as of the fiscal beginning of the year. Panel A (B) plots quarterly sales growth around the recall event when 50th (75th) percentile of *Ratio* is used as the cutoff.

Panel A: *Ratio* > 50th Percentile



Panel B: *Ratio* > 75th Percentile

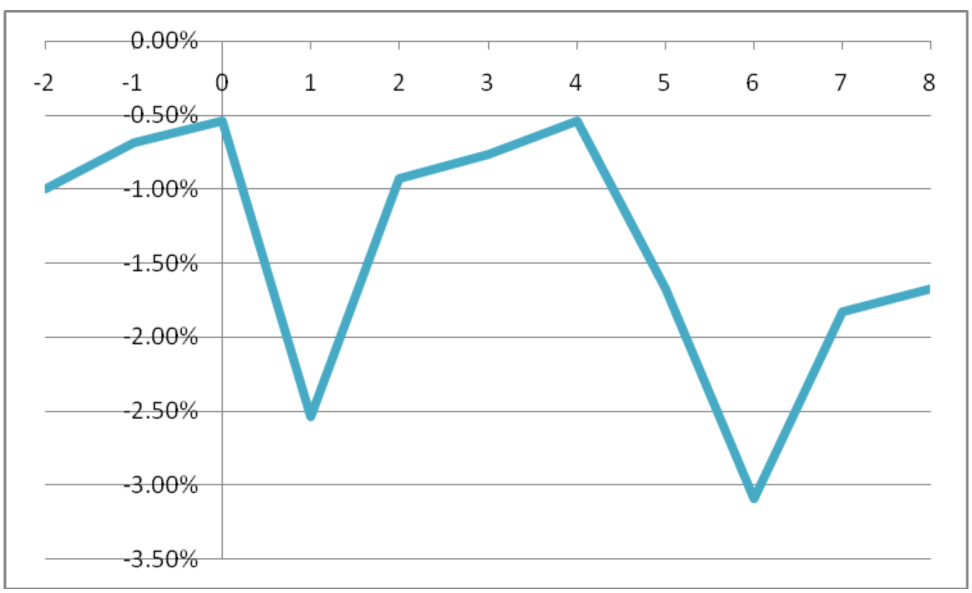
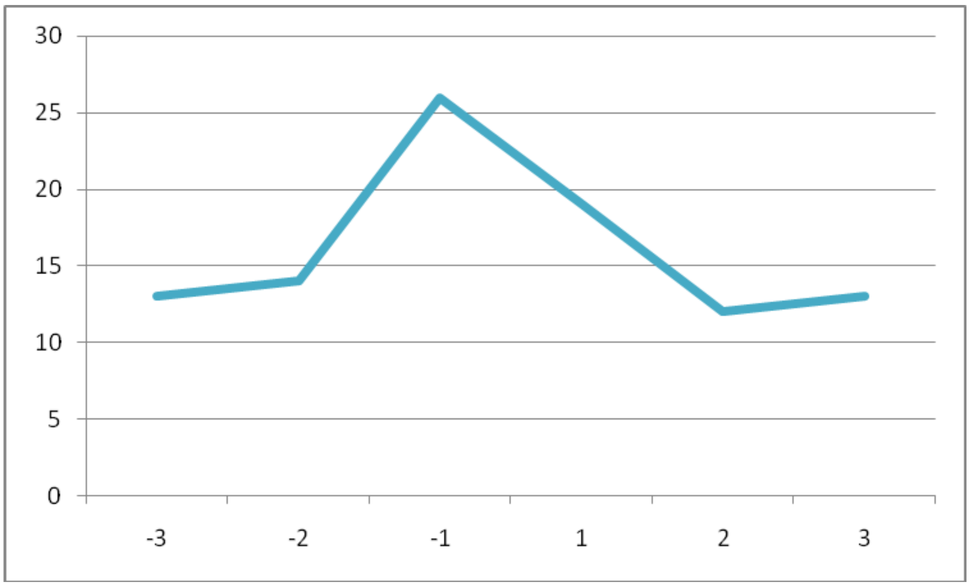


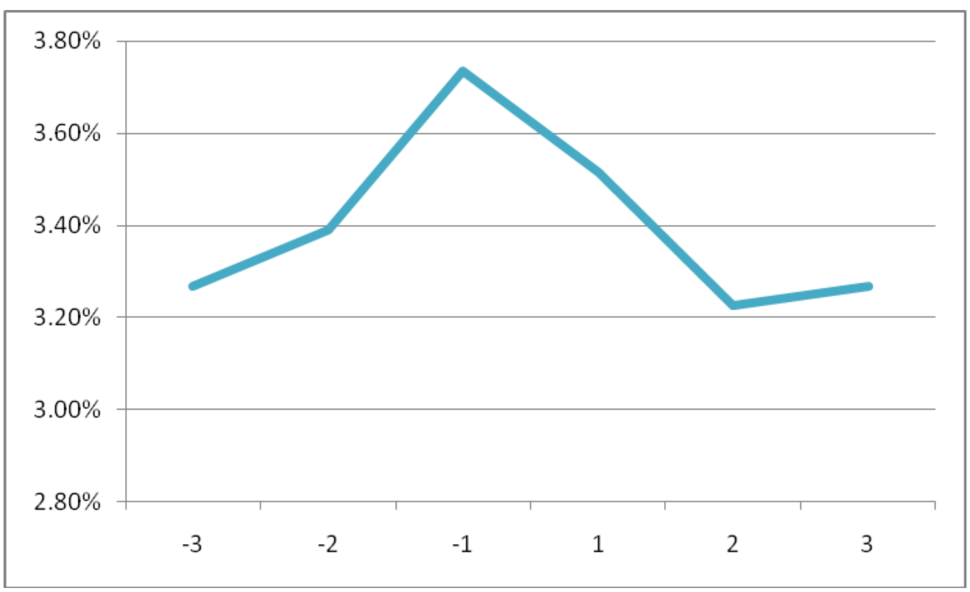
Figure 3. Issuances around Recall Events: *Ratio* > 50th Percentile

The issuance sample consists of firm-month observations for public vehicle manufacturers that issued debt or equity from January 1970 to July 2010. *Ratio* is the number of units affected by the firm's recall scaled by total number of employee as of the fiscal beginning of the year. The event date (month) is the date (month) in which a recall file with *Ratio* above the 50th percentile is submitted to the National Highway Traffic Safety Administration. Only large issuances in the event window of (-3, +3) relative to the recall month are included. For public debt issuances, the cutoff is 1.5% of the book value of assets, and for equity issuances, it is 3% of the book value. Issuances occurring in a recall month but before (after) the recall date are classified as issuances in event month -1 (+1). *# of Issues* is the number of equity or public debt issuances. *Issue Amount* is the issued amount as a fraction of book value of assets as of the fiscal beginning of the issuance year. For Panel A, the recalls corresponding to the event month are included in month -1 if they occur prior to the recall announcement date and in month +1 if they occur on or after the recall announcement date.

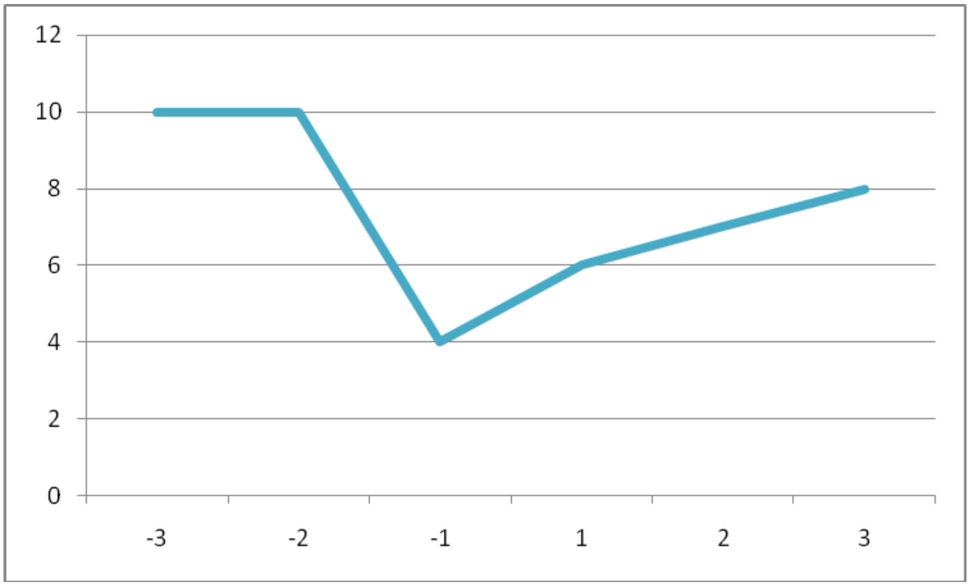
Panel A: *# of Issues* around Firm-Initiated Recalls



Panel B: Median of Issue Amount around Firm-Initiated Recalls



Panel C: *# of Issues* around Government-Initiated Recalls



Panel D: Median of Issue Amount around Government-Initiated Recalls

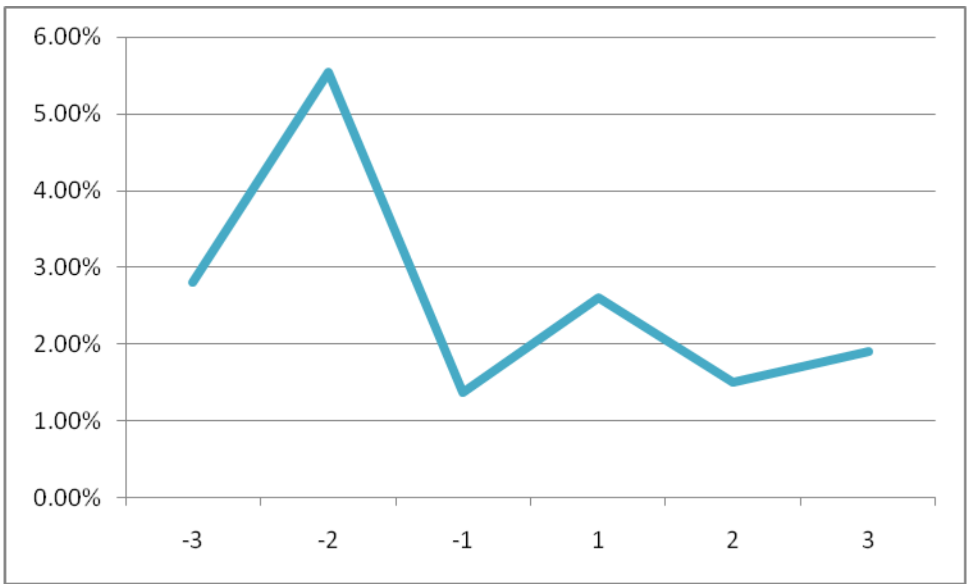
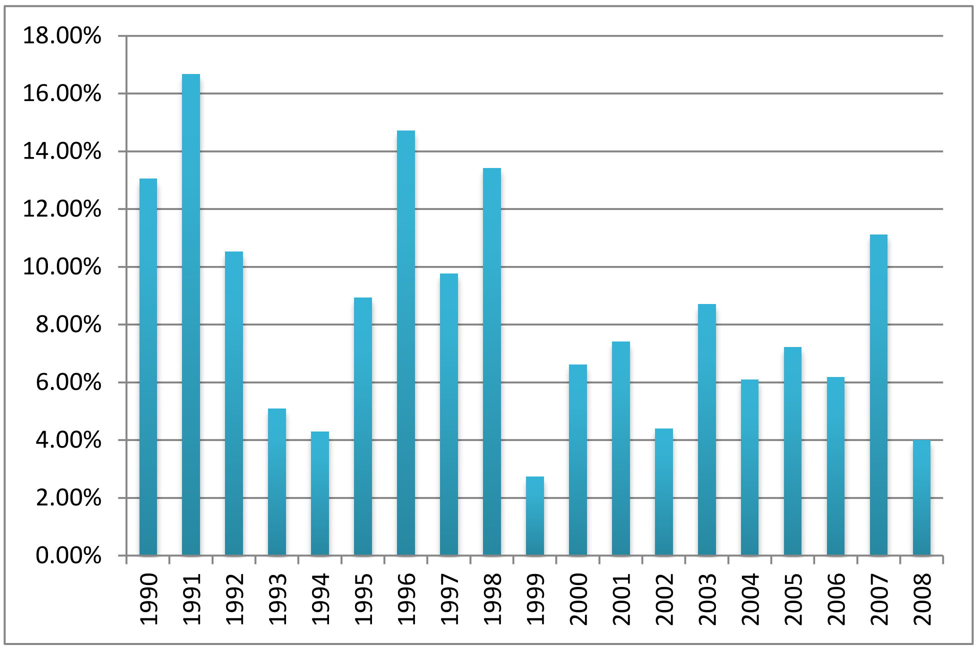


Figure 4. Regulatory Proactivity

This chart shows the average ratio of number of recalls subject to National Highway Traffic Safety Administration investigation over total number of recalls initiated by the manufacturer or the government for all vehicle manufacturers for each year. Only recalls initiated within eight hundred days after the beginning of manufacturing and with above-median *Ratio* are included. *Ratio* is the number of units affected by the firm's recall scaled by total number of employee as of the fiscal beginning of the year. Pre–Transportation Recall Enhancement, Accountability, and Documentation (TREAD) and post–TREAD periods are 1990–2000 and 2001–2008, respectively.

Panel A: Regulatory Proactivity by Recall Year



Panel B: Regulatory Proactivity before and after TREAD Act

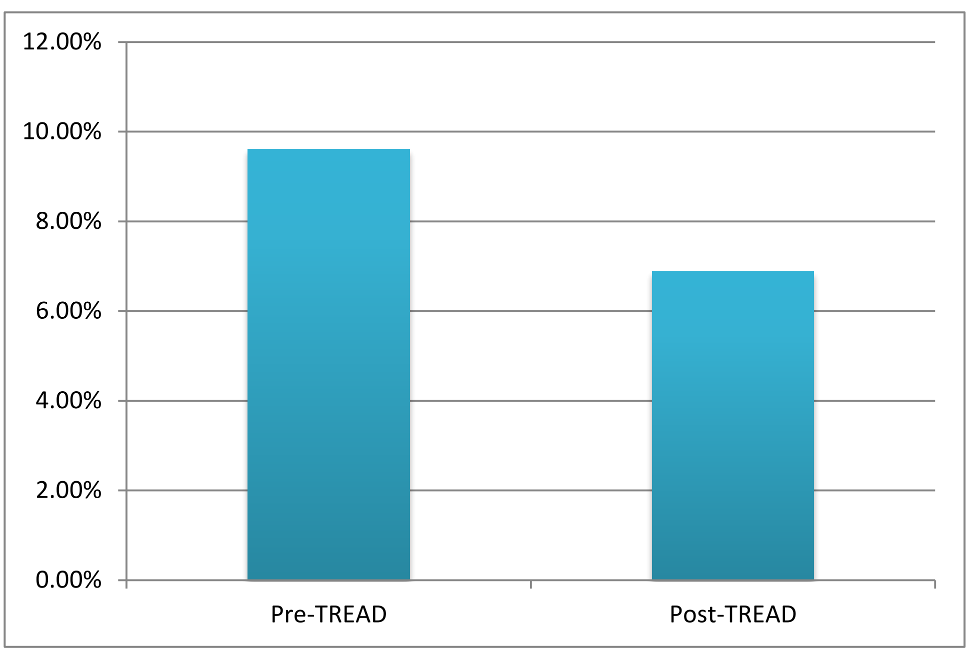
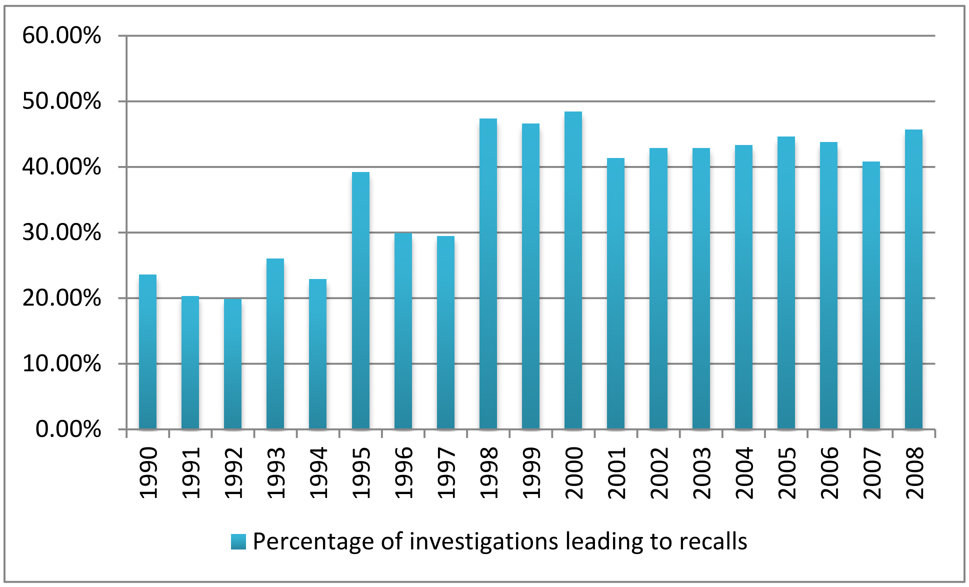


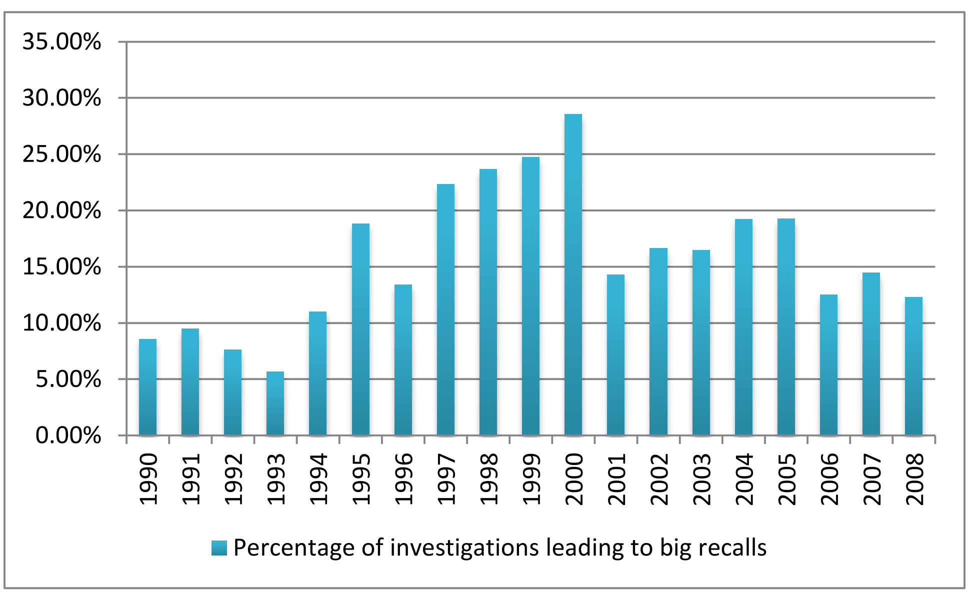
Figure 5. Defect Investigations Leading to Recalls

This chart shows the fraction of investigations of alleged defects initiated by the National Highway Traffic Safety Administration each year that lead to recalls. Panel A shows the fraction of recalls of all sizes following the opening of an investigation. Panel B shows the fraction of big recalls following the opening of an investigation. Big recalls are defined as ones that have *Rate* ≥ 75%. *Rate* is the estimated number of defective products in a recall file scaled by *Days of Delay*. Panel C shows fraction of small recalls following the opening of an investigation. Small recalls are defined as ones that have *Rate* < 75%.

Panel A: Investigations Leading to Recalls



Panel B: Investigations Leading to Big Recalls



Panel C: Investigations Leading to Small Recalls

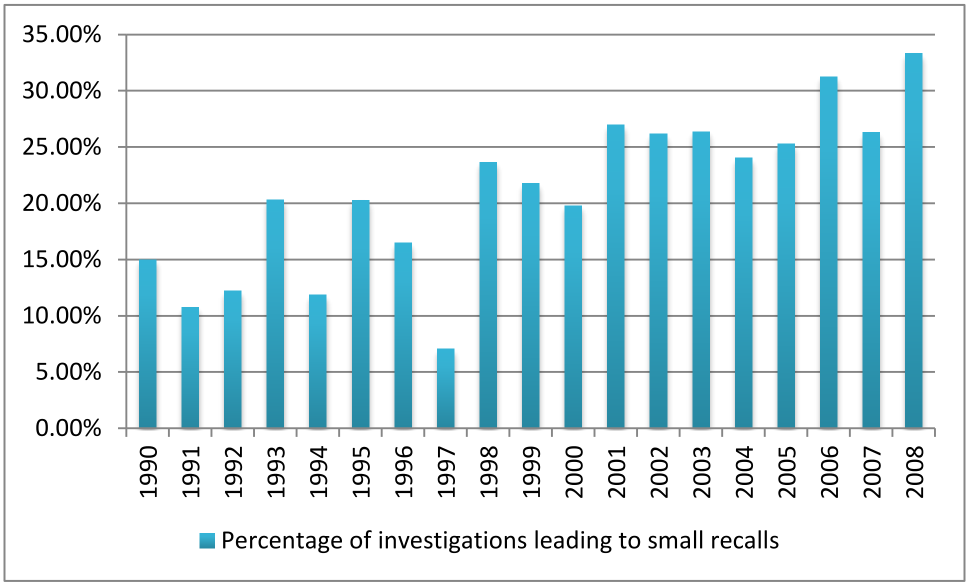


Figure 6. Duration of Investigations of Defects

This chart shows the duration of investigations of alleged defects initiated by the National Highway Traffic Safety Administration each year. Duration is measured as the number of days from the opening to the closing of the investigation.

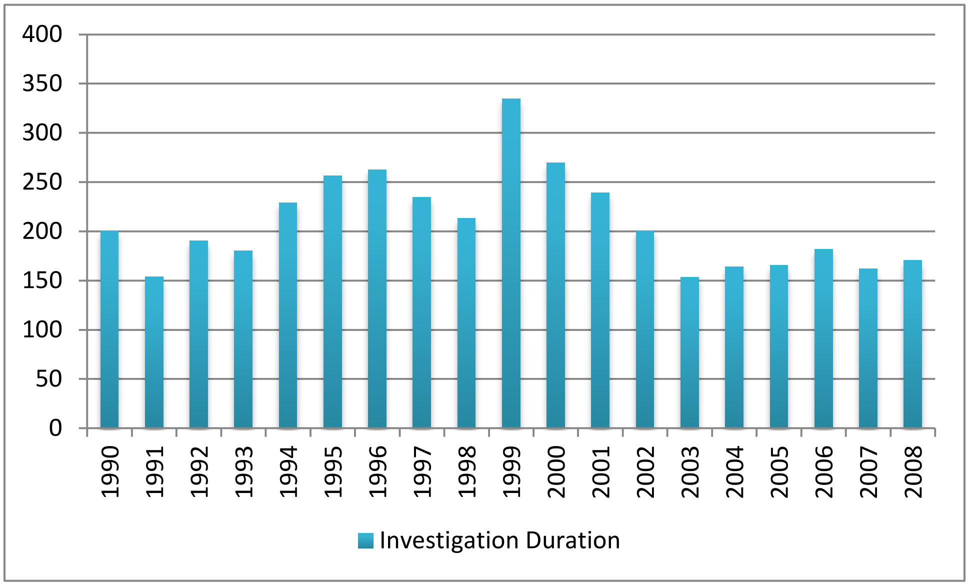
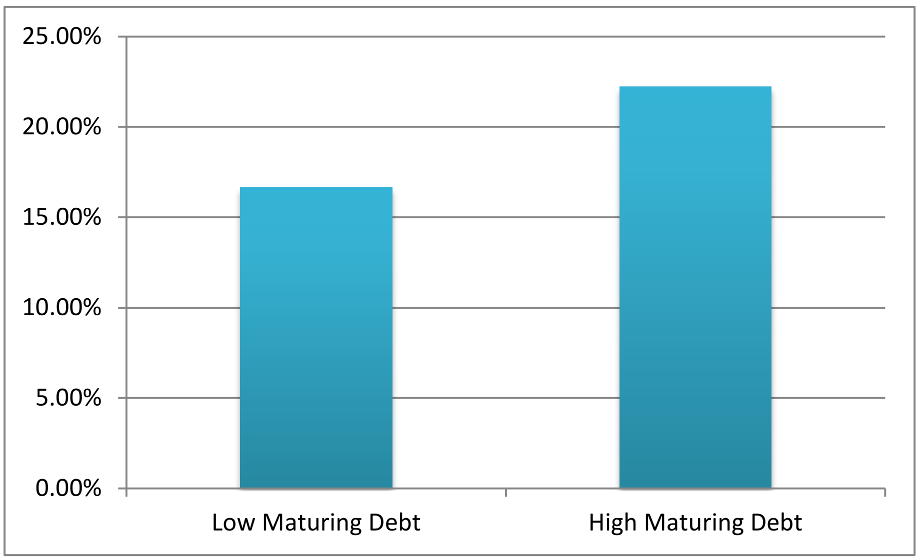


Figure 7. Maturing Debt and Early Recalls

This chart compares the fraction of early recalls that are initiated by public vehicle manufacturers with high and low levels of maturing debt before and after enactment of the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act of 2002. Only recalls with *Rate* ≥ 75% are considered. *Rate* is the estimated number of defective products scaled by *Days of Delay*, defined in Table 2. Early recalls are defined as those that occur earlier than one hundred days prior to the fiscal end of the manufacturing year. In each year, high and low maturing debt recalls are classified based on whether maturing debt is above the sample median. A recall from the high maturing debt recall subsample is matched with one from the low maturing debt recall sample based on two criteria. (1) For both recall campaigns, manufacturing starts in the same calendar month (to control for the time interval between start of manufacturing and the one hundred days from fiscal year-end cutoff). (2) Both recalls are initiated by the same firm (to control for firm-specific effects). Because the second criterion requires that the two recalls occur in different years, among all recalls from the low maturing date subsample that satisfy the above two criteria, we choose the one that is in the closest fiscal year.

Panel A: Pre–TREAD Period



Panel B: Post–TREAD Period