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

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JEL Classification Codes: G32, G38

Keywords: Product Recalls, Vehicle Recalls, NHTSA, TREAD Act, Capital Structure, Debt Maturity

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Abstract

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In 2014, General Motors recalled 29 million cars in North America in connection with faulty ignition switches, issuing 45 recalls in that year alone. As is now well documented, GM had been aware of the ignition switch problem for more than a decade. A probe by U.S. Atty. 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, but completely absolved GM's top executives from responsibility, noting that the information about the problem did not reach their level of the company until January, 2014.

While the ignition switch problem, the associated accidents and fatalities, and GM's apparent failure to address a defect that, if handled in a timely manner, would have cost little, have attracted much recent attention, vehicle recalls are very common occurrences for major US car manufacturers. Indeed, since 1966, the "big three" have issued multiple recalls almost every year, totaling well over 1000 recalls over this period. While many of these recalls have affected a relatively small number of cars, there were 724 recalls during this period (1966-2010 July) affecting more than 100,000 defective vehicles. In this paper, we focus on larger recalls and provide evidence that the timing of these recalls are strategic decisions that have implications for shareholder wealth. In particular, we show that the timing of recalls is chosen in a way that is likely to soften the impact of recalls on the cost of raising finance. Since it is unlikely that considerations such as the cost of the finance can be reflected in the decision making process 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] More

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

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 the pursuit of 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 (henceforth, NHTSA). Many have questioned the role of NHTSA in connection with GM's recalls – the agency received the first complaints as early as 2003 but repeatedly ignored consumer complaints about the problem. A New York Times article summarizes the findings of a detailed investigation 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".

It has been argued that NHTSA's priorities changed during the last decade due to improved vehicle safety and lower incidence of fatalities, so that the agency was spending significantly more resources, for example, on generating star safety ratings for different models that manufacturers used for their marketing campaigns than for investigating defects. We argue that another significant factor that affected regulatory proactivity was passage of the TREAD Act (signed into law by President Clinton in November, 2000). The Act greatly increased the information gathering and reporting requirements on manufacturers, which might have been

[2] Mitnic (1980) defines regulation as follows: 'Regulation is 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, September 14, 2014, for a detailed account of the New York Times' investigation into NHTSA's handling of major safety defects.

otherwise privately suboptimal.[4] However, while increasing information production, the law also significantly increased the lag in reporting[5] and the time it takes for the regulator to process information.[6] In addition, the combination of improved vehicle safety and more information about potential vehicle defects with the vehicle manufacturers as a result of the TREAD Act is likely to have created "regulatory slack", with NHTSA now 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 the Act, creating an opportunity for manufacturers to strategically delay their recalls if it was in their interest to do so. In section 5.4.1, we present several pieces of evidence suggesting that the post-TREAD period was indeed one in which proactivity was lower relative to the earlier decade.

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 happen within 2 years from the start of manufacturing. However, as these two examples suggest, because of the right-truncation problem, we may not have observed some potentially very large recalls yet, thereby making it difficult to make unconditional statements about the effect of financial structure on recall timing or likelihood. Therefore, we examine a setting in which financial structure can only affect firms' incentives to delay or hasten recalls by at most a few months. Specifically, we examine how the amount of previously issues long-term debt that is maturing in a given year affects the likelihood of firms to issue recalls earlier than an arbitrary cut-off point

[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 the 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) on potential problems. The richest and most effective data for the EWS are in text form, and comprise of comments from repair technicians and customer complaints. Analyzing this data can be a time-consuming and challenging task.

in that year (for vehicles whose manufacturing commenced in that year).[7] We find that after the TREAD Act when vehicle manufacturers were expected to have better information about vehicle defects but NHTSA became less proactive compared to the earlier decade, manufacturers were more likely to initiate early recalls. However, the presence of larger quantities of maturing debt had opposite effects on the incentive for early recalls: whereas post-TREAD, more maturing debt led to later recalls, the opposite was the case in the earlier decade. It is this effect of maturing debt on recall timing that 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 the vehicles until after the debt has been paid. However, if this were the case, we would expect the positive effect of debt on delay to be stronger when the regulator is more proactive, which is the opposite of what we find. Moreover, it is unclear why such an effect would hold in the post-TREAD period, and not the prior period. Nevertheless, to directly address this issue, we obtain a sample of recalls that were preceded by a "serious" consumer complaint to the NHTSA about product 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 here we know that the manufacturer has received some signal about a potential problem. We examine how the likelihood of a manufacturer initiated recall 100 days prior to the end of the year in which the first complain is

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[7] This cut-off point in our regressions is 100 days before the fiscal year end, which is roughly the mid-point between the time between the commencement of manufacturing and the fiscal year end. However, our results are robust to alternative cut-offs.

received is affected by 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 period 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 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 (population). As a result, higher levels of maturing debt would be associated with delayed (earlier) recalls in states without (with) regional offices, with the former effect being attenuated in cities with high population (density). We find very consistent results.

In Section 3, we develop a theoretical framework that captures how short-term financing needs affect firms' recall timing decisions, and how this effect depends on the proactivity of the regulatory regime. 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 point of time when the firm needs to raise external financing. There are several costs associated with recalls. First, there are reputational costs, since by recalling, a firm "admits" that there is a problem.[9] Second, the recall campaign itself, and replacement of the defective parts, is costly. Third, sales could freeze while the recall

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

[9] In the US Justice Department's 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.

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 internal cash flows, which may matter if the recalls occur immediately prior to dates at which the firm has relatively inflexible external financing needs, such as previously issued debt that is about to become 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 prior to recalls. For regulator initiated recalls (Panel B), issuance activity peaks a few months prior to the eventual recall, since firms 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 (Myers (1977), Jensen and Meckling (1977)). We add to this literature by showing that financial

[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)).

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 mainly has focused 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), and 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,[12] indicating that there are other costs. We find that large recalls are associated with a higher likelihood of rating downgrades for firms with high levels of maturing debt. This suggests the higher cost of external finance as a possible explanation for the loss of firm value beyond the direct costs of recall. Finally, our results also 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 the vehicle manufacturers' own effort.

The rest of the paper is organized as follows. Section 2 provides and 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 (NHTSA) requires a vehicle manufacturer to initiate a recall in the following two scenarios. First, a motor vehicle or a motor vehicle

[11] In a recent paper, 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 losses due to lost demand, inventory losses and refund, litigation costs, and the costs to remedy the defective product.

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

Investigations on vehicle safety issues can be initiated by either the manufacturer or the NHTSA. Most decisions to conduct a recall and remedy a safety defect, however, are manufacturer initiated, that is, the investigation is initiated voluntarily by the manufacturer. Through their own tests, inspection procedures, and information-gathering systems, manufacturers often discover 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 Office of Defects Investigation (ODI) of NHTSA 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, in which event 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 investigation by the NHTSA, the manufacturer can initiate a recall based on its own investigation and information. Recall

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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 equipments 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 that exists in a motor vehicle or a motor vehicle equipment that either poses a risk to motor vehicle safety, or may exist 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.

campaigns in which the investigation is initiated by the NHTSA are called *government initiated recalls* in this paper.[16]

2.1 The TREAD Act

The TREAD Act was signed into law by President Clinton in November, 2000, and represents a major step in the evolution of product safety regulation. The law was in response to the significant number of injuries and fatalities associated with the 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 comprises of 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 manufacturers as it may deem necessary for its investigations, which requires the firm to maintain a "TREAD picture" at any point of time.

Of its several components, the "Early Warning Requirement" is perhaps the most significant from the perspective of product recall incentives of vehicle manufacturers. According to this component of the law, 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. There is criminal liability if information voluntarily withheld regarding defects subsequently leads to injury or death.

[16] Both the above types of 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.

For our purposes, several features of the reporting under the TREAD Act are worth emphasizing. First, although it requires regular reporting, the time lags involved in the reporting of information under the TREAD Act can be long. NHTSA gives manufacturers up to 120 days from the closing of the quarter to submit a report. This effectively means that an incident that occurred in the first quarter could be reported in the third quarter, and thus gives a manufacturer enough slack to delay reporting if it is in the latter's interest. Second, the volume of information that needs to be reviewed can be substantial, both for the reporting firm and the regulator. Some of the most useful information for the Early warning System comes from field reports, which are in unstructured text form. A typical automotive manufacturer can produce incident reports that can run into millions in a given week.

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

3. A Model of Product Recall Timing

In this section, we develop a simple model of product recall 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 tradeoffs involved, and then extend the model to derive a richer set of implications.

3.1 A Preliminary Setup

Panel A of Figure 1 presents a timeline for the preliminary model. Assume that a product is defective with probability α. The manufacturer, at an initial time point 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 $1 - \phi$).

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

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

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

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 if the product 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 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 iff $c_0 < cp$. (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, a few preliminary observations immediately follow:

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

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

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

One reason why 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

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. We will assume that in the post-TREAD period, firms are more likely to have the more precise signal than in the pre-TREAD period (by which we shall refer to 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 with the 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 period at some interim point of time in the post-TREAD period than in the pre-TREAD.

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 1, at a later time t_2. The corresponding cost of recall 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 at a point of time 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 corresponding to 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 pro-active 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 corresponding to 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 rather than 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, while 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 tradeoff for firms with lower quality signal. To see this, assume

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

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, the following are the testable implications of our model:

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)[19] and delayed recalls if the regulatory regime is not very proactive (in response to higher average signal quality with firms).

4. Data

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.

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 1. 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.

Our data comes from the monthly recall reports since 1966 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/equipment make, vehicle/equipment model and year, 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 the recall initiator. By constructing a web crawler to extract the monthly recall reports on its website, NHTSA makes the above statistics flat files that are electronically available. Under each recall campaign number, NHTSA creates multiple entries if more than one model type sold by a particular manufacturer or several components installed into one vehicle were affected, making it possible for multiple entries to 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 us with a total of 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, and 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.

For every five-year period from Janurary1966 to July of 2010, Table A1 in the Appendix describes the number of recall campaign files and the potential number of units affected. The statistics show an increasing trend of vehicle safety-related recalls in terms of frequency and scope. Table A2 in the Appendix summarizes the recall characteristics over defective components.[20]Service brakes, equipments, and fuel systems, in that order, are the most common components that are responsible for safety-related recalls.

In order to match COMPUSTAT data with the NHTSA recall database, we manually look up in the company website or in Bloomberg Businessweek (http://www.businessweek.com/) the name of every vehicle firm appearing in each recall file to identify whether the company was publicly listed, or affiliated to a listed company. Among the 1,548 different names for recalling firms that appear in the NHTSA monthly recall reports, we identify 300 as belonging to the headquarters or divisions of 149 different public firms, and 14 as subsidiaries of 10 public firms where we can identify the exact year in which the subsidiary was acquired.[21]

We further restrict our sample to firms that have gvkey either in COMPUSTAT North American, or Global. We then create a panel dataset by matching financial data with NHTSA recall files based on firm gvkey and fiscal year. We further delete observations that do not have financial data as of the beginning of manufacturing year, including the current portion of long-term debt, long-term debt due beyond one year, EBIT, sales growth rate, cash and short-term

[20]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.
[21] We delete recall files initialed by subsidiaries where we do not know the exact date at which the subsidiary was acquired. This date is important because for our tests, we control for characteristics of the company that initiates the recall.

investments, inventory, and total asset. We also exclude observations that do not have information regarding the state or country of incorporation. Our final sample comprises 5,831 recall files initialed by 118 public firms. Table A3 in the Appendix provides an overview of the steps in our sample construction.

Our analysis focuses on vehicle manufacturers rather than 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 since the size of the recall (the number of units affected) is likely to matter for the timing of 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 product for each public firm on its company website to determine whether the firm is a parts supplier or manufacturer. We identify 53 public manufacturers.[22]

Table 1 shows how the sample manufacturing firms are distributed over various stock exchanges. The 53 firms come from 9 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, 9 (16.98%) are listed in Japan, and 5 (9.43%) listed in Germany, and are responsible for 69.97%, 8.33% and 9.27% of the total recalls events, respectively.

5. Preliminary Analysis

In this section, we first present some descriptive statistics for our regression sample. We then present evidence suggesting that large recalls are costly, especially when firms have large amounts of previously issued debt maturing in the same year. Finally, we present some especially striking evidence suggesting that when large issuances of debt and equity and large

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

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

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 comprises of recalls for which a variable (Rate) that represents the rate of sales of the affected vehicles prior to the recall exceeds the 75th percentile values of the corresponding distribution for the sample in Panel A. Rate is defined as the number of vehicles (units) affected by the defect divided by the number of days of 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.

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 from the perspective of the financial impact of these recalls, and hence should be excluded from considerations of 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, since the most important cost of recalls is likely to be in terms of interruption or loss of sales, the average number of units sold per day seems to an appropriate choice for a sample of recalls that are subject to strategic recall timing. As we note below, the average number of days of recall delay is comparable across the two subsamples when partitioned on the basis of Rate.[23]

The upper section of each panel in Table 2 reports characteristics of the recalls. With 100 days from the fiscal-year end of the year in which manufacturing begins as the cutoff for early recalls, we note that about 22-24 percent of the recalls occur before this cutoff. 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 300 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 latter 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 comprises of the larger recalls.[24]The mean number of models per recall file is around 4, and the median is 2. 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 towards the beginning of the year. Thus, the 100 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,

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[23] 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 from us on 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.

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

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 the "Big 3" 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 manufacture 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, 3 different recall announcements occur for different batches of vehicles that were manufactured in the same year.

5.2 The Financial Impact of Recalls

Previous studies have documented stock price declines around recall announcements, confirming that recalls are costly.[25] Here, we examine how recalls affect sales, and credit ratings.

In Figure 2, we plot median 3-digit SIC 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, whereas in Panel B, the cutoff is the 75th percentile of the distribution. The panels show

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[25] 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).

a similar pattern. The industry-adjusted sales growth of the recalling firm drops sharply in the quarter immediately after the recall quarter, and then rebounds. It again drops after 6 quarters, possibly reflecting the fact that sales taper off after the launch of new models that were subject to an earlier recall.

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 1 if the firm has an S&P rating on long-term debt in the year after recall year that is lower than that in the year before the recall year. ‘Big” is a dummy variable that takes the value of 1 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 include the “Big” dummy, its interaction with a dummy variable (H1) that equals 1 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 shown within curly brackets. Columns (3) and (4) present results from a linear probability model, with firm-fixed effects being included in the specification for 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 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 potentially adverse impact of such recalls (as evidenced in the effect of big recalls on credit ratings discussed earlier) 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.[26]

The evidence is striking. For manufacturer initiated recalls, there is a dramatic increase in the number and median volume of issuance one month prior to the recall month relative to 3 months before. This is exactly what we would expect if firms delay recalls to avoid disruptions to capital raising activity. Note that 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 that an investigation is ongoing 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

[26] 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%.

recalls, possibly due to the uncertainty about the exact timing of the recall. Interestingly, since there is no preemptive early recalls in these cases, the issuance activity immediately after the recalls are lower than two or three months before.

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 has been alleged to be 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). It has been argued that safety investigation has been very far from NHTSA's mindset in recent years[27] – the Agency being more interested in helping car manufacturers sell cars by touting the safety of their vehicles under the Agency's seal of approval than in safety investigation. While the agency's budget for safety defects investigation has been around 1 percent of its total budget for each of the last 6 years, the share of funding for its ratings program as well as other divisions has increased.[28]

In the next subsection, we document three types of evidence that suggest that the post-2000 period was associated with less regulatory proactivity than the preceding decade. Some of

[27] 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 there were no cases in which a defect in the vehicle was identified.

[28] According to a New York Times article, even though the Agency's defects office added more staff soon after the TREAD Act 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 work force 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).

the evidence suggests 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 why this could happen is that with the law now requiring the vehicle manufacturers to 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 now being produced was simply too much for the regulator to cope with. However, it is also possible that with technological improvements reducing the risk of fatalities, defects investigation became 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.

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 the TREAD Act compared to 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 1990-2008, while 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 50^{th} 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 in less than 800 days from the beginning of manufacturing date. In Panel B, the average for the pre-TREAD years is 9.6%, whereas that for the post-TREAD period is about 6.9% -- showing a 30% decline. Moreover, in 4 of the years in the prior decade, the ratio exceeds 12%, but it does not reach that level for any of the years in the post-TREAD period.

As recently as in 2013, NHTSA was ostensibly bowing to pressure from vehicle manufacturers and agreeing to their demands for scaling down NHTSA-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 defect investigations 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.

Finally, in Figure 6, we plot 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 earlier decade.

5.4.2 The TREAD Act, Maturing Debt, and Recall Delay

Regression Framework

In this section, we examine how financial structure affects the recall incentives of vehicle manufacturers. Since 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 800 days of the beginning of manufacturing (however, our results are robust to alternative truncations). Our results are robust to alternative truncations, such 1000 days or 1200 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 debt that is currently maturing. Second, especially in the light of the recent spate of large scale recalls by GM for problems that were known a decade ago, there clearly is a right-truncation issue if we do not restrict the time to recall. Finally, our focus here is to understand firm's 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 only revealed after debt maturing by the end of the year 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 x 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 the manufacturing begins.

The logic is as follows. As implied by our model outlined in Section 3.2, a higher level of maturing debt could either lead to later or earlier recalls, depending on the quality of information regarding potential defects with the firm and the nature of the regulatory environment. For example, if the information quality with a firm is not very good, the firm might choose to wait until less costly information in the form of consumer complaints or feedback from dealers or the regulator accumulates. Higher levels of maturing debt exacerbates such incentives, since it is costly to recall immediately prior to the maturity of the debt or the time financing is to be arranged to repay the debt. A higher level of maturing debt will not only exacerbate these 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.

On the other hand, 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 precisely 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 more 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, although since information quality is likely to be negatively associated with regulatory proactivity, the negative effect is expected to dominate.

For our test, we construct, as our dependent variable, an indicator that takes a value of 1 if a recall (either manufacturer or government initiated) occurs after the cutoff, which is 100 days in Table 4. Our results are robust to a number of alternative cutoffs and truncations of recall delay, 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.[29] Thus, we exclude government initiated recalls before the cutoff, since these do not tell us whether the firm intended to delay beyond the cutoff.[30] We control for long-term debt, cash holdings, inventory, profitability, sales growth, firm size, and the logarithm of the number of models in the recall campaign.

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

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

related to the likelihood of a late recall since 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 1 for manufacturing year in the post-TREAD Act period (specifically, after November, 2000), and zero otherwise.[31] 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 of the Low Maturing Debt (LMD) subsample depending on whether that firm-year is characterized by maturing debt levels that are above or below the sample median. For each recall above the Rate ≥ 75^{th} 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 there are multiple recalls that 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 to 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.

In Table 4, we report three sets of results. Column 1 reports results from a Probit regression, and Column 2 reports the key marginal effects. Since Stata's "dprobit" command does not generate the correct marginal effects for interaction terms, we report the corrected marginal effects within curly brackets in Column 2. Columns 3 and 4 report results for the linear probability model. We include firm fixed effects for the model corresponding to Column 4.

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

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. Since 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 US-listed firms, and the country for non-US listed firms. In addition, we include fixed effects for the component affected, and year fixed effects.[32]

The results indicate that TREAD 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, whereas 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%. On the other hand, 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"

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

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

during the period from commencement of manufacturing to the date debt is due is not affected by the level of maturing debt. It is possible, however, that those with higher levels of maturing debt systematically receive signals later than those with lower levels of maturing debt. One reason why 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. [33]

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 definition would be in terms of the time it takes 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.

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 problem could potentially exist. This is the sample of recalls that are

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

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 defect investigations 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/equipment, a description of the defective component, the date complaint 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 that reports that a vehicle was involved in a crash, a fire, or injuries and fatalities as a “serious complaint”.

Table 5 describes the Serious Complaint sample. We reports results for the overall sample, since 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 those for the one reported in Panel B of Table 2. *Recall timing* indicates the percentage of recalls that are issued after 100 days from the end of the fiscal year in which the complaint is received. 70% of the recalls are issued later than this cutoff. Not surprisingly, the percentage of government initiated recalls is considerably higher at 22%, compared to 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 the first serious complaint is received.

We define an “early recall” as a manufacturer initiated recall that occurs within 100 days of the end of the fiscal year in which the first serious complain associated with a recall was received, and if the recall (either manufacturer or government initiated) occurs after this cutoff, the recall is considered “late”. Our dependent variable is a dummy variable that takes a value of 1 if the recall is late, and zero if it is early. We include the same set of control variables as those 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.

Consistent with our earlier results, the likelihood of an early recall increases after the TREAD Act – 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 that for the post-TREAD period. The net effect of a one standard deviation increase in the in the level of maturing debt after the TREAD Act is a 24 percentage point increase in the probability of a late recall for the Probit specification, compared to 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 such 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.[34] 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 (earlier) recalls in states without (with) 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.[35]The results show that higher levels of maturing debt lead to later recalls in states where the NHTSA does not have regional office (the effect in marginally significant on OLS regression when firm fixed effects are added), but in states where a regional office is present, the effect is either insignificant or has 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

[34] There are NHTSA regional offices in 10 states: Massachusetts, New York, Maryland, Georgia, Illinois, Texas, Missouri, Colorado, California, and Washington.

[35] 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 800 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 1500 days.

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 the passage of the TREAD Act, firms are less likely to delay recalls beyond 100 days (alternatively, 80, 120, or zero days) from the end of the fiscal year in which the manufacturing of the vehicle commences, compared to the previous decade. 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, whereas the opposite is the case in the previous decade. While the first of these results is consistent with a variety of explanations including more informative signals about product defects with manufacturers, the latter suggest a strategic motive for timing recalls related to how they impact the cost of external finance. In particular, it is consistent with the notion that NTHSA became less proactive after the passage of the TREAD Act, and this enabled manufacturers to delay recalls when that served their interest without regulatory pressure. 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, but 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- July 2010. The numbers shown are aggregated over 5-year periods. # of manufacturer/supplier initiated recalls is the number of manufacturer or supplier initiated recall reports submitted to the NHTSA. # of units is the estimated number of defective products in each recall file. Manufacturer or supplier initiated recalls are recalls initialed by vehicle manufacturer or parts supplier firms rather than by NHTSA.

Sample Period	# of recalls	# of manufacturer/supplier initiated recalls		# of units	# of units in manufacturer/supplier initiated recalls	
	A	B	B/A	C	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. # of recalls is the number of recall reports submitted to the NHTSA. # of units is the estimated number of defective products in each recall file.

Component Name	# of recalls	% of # of total recalls	# of units	% of total # 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	N
Total entries from Jan, 1966 to July, 2010 (vehicle manufacturers and parts suppliers)	84,580
that have non-missing date for the start of manufacturing	60,303
Total recall files with distinct recall campaign numbers	11,521
that have non-missing date at which a recall report is filed	11,512
that have non-missing # of units affected in each recall file	11,499
that have recall files being submitted later than the date at which manufacturing begins	11,492
that have no recall "duplicates"	11,430
that are public firms or the subsidiary of public firms	5,473
that satisfy criteria for inclusion in the regressions	3,160
that are vehicle manufacturers	2,843

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

This table presents the estimates of the interaction between maturing debt and large recalls on the probability of credit rating downgrade for public vehicle manufacturers. The dependent variable is a dummy variable defined as one if a firm's Standard and Poor 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 deprobit coefficients for key independent variables. The mean of correct marginal effect of a change in two interacted variables for probit model is presented in the curly bracket. 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 non-missing credit rating, and zero otherwise. Big is a dummy variable defined as one if the aggregated # of units scaled by total # of employees is above median in the sample where recall occurs, and zero otherwise. Ln (# of Employees) is the logarithm of total # 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 US (an international) firm is incorporated. Year is the fiscal year. All financial variables are as of the beginning of fiscal year. Please refer to Table 2 for the definitions of other variables. Standard errors in the brackets are clustered at firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
	Probit		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			
Adj 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 only over stock exchanges. # of manufacturers is the number of public vehicle manufacturers. # of recalls is the number of recall reports submitted. # of units is the estimated number of defective products in each recall file.

Stock Exchange	# of manufacturers	% of total # of manufacturers	# of recalls	% of total # of recalls	# of units	% of total # of units
NYSE	23	50.00%	1983	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%	2843	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 NHTSA. Panel A presents summary statistics on the entire sample. Panel B presents summary statistics on the subsample where Rate is above the 75th percentile. Recall timing is a dummy variable defined as one if a firm files a recall report later than 100 days prior to the fiscal end of the year 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 initialed by the NHTSA rather than 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 terms of US 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

	N	Mean	std	25th	50th	75th
			recall characteristics			
Recall Timing	2830	0.76	0.43	1	1	1
Days of Delay	2843	301.16	208.6	122	253	444
GovtIn	2843	0.07	0.25	0	0	0
# of Units	2843	29.24	137.64	0.21	1.60	12.3
Rate	2843	87.80	337.95	1.06	7.98	56.16
# of Models	2843	3.55	4.57	1	2	4
Interval	2843	232.38	77.13	152	226	303
			financial characteristics			
Maturing Debt	2843	0.05	0.05	0.01	0.05	0.07
Long-term Debt	2843	0.17	0.11	0.08	0.17	0.24
EBIT	2843	0.06	0.07	0.02	0.05	0.09
Sales Growth	2843	0.08	0.20	-0.02	0.07	0.16
Cash	2843	0.11	0.07	0.06	0.09	0.14
Inventory	2843	0.15	0.11	0.06	0.12	0.20
Total Asset	2843	91.87	115.70	4.39	26.66	180.60

Panel B: Rate>75th

	N	mean	std	25th	50th	75th
			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 manufacturers. Recall Frequency is the total number of manufacturing years, as a percentage of the number of years a public manufacture 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 3s refers to Ford, GM and Chrysler in US; Toyota, Honda and Nissan in Japan; and Daimler, BMW and Volkswagen in Germany.

Group	Recall Frequency			# of Recalls/Year			
				Mean	50th	N	# 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
		Mean	50th	Mean	50th	N	# of recalls
Big 3s		92.88%	100.00%	9.67	7	189	1827
Non-Big 3s		67.94%	73.17%	2.97	2	342	1016
Full Sample		76.82%	74.36%	5.35	3	531	2843

Table 4. Effect of the TREAD Act on Recall Delay

This table presents estimates of the effect of the TREAD regulation 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 defined in Table 2. The dependent variable is a dummy variable defined as one if a manufacture or government initiated recall occurs later than 100 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 deprobit coefficients for key independent variables. The corrected marginal effect of a change in two interacted variables for probit model is presented in the curly bracket. 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 US (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. Please refer to Table 2 for the definitions of other variables. Standard errors in the brackets are clustered at firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
	Probit		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			
Adj R^2			0.13	0.13

Table 5. Sample Summary Statistics: Complaint Sample

This table presents summary statistics on the complaint sample for public vehicle manufacturers. Recall timing is a dummy variable defined as one if a firm files a recall report later than 100 days prior to the fiscal end of the year in which customers file the first “serious complaint” to NHTSA, and zero otherwise. A serious complaint is defined as a complaint filed by customers that either 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 initialed by NHTSA rather than 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 terms of US 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.

	N	mean	std	25th	50^{th}	75th
			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 TREAD regulation 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 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 with crash or fire, or reports the number of fatalities or injuries. Regression results are reported where 100 days is used as the cutoff. Complaints occurring after the cutoff are excluded. Column 1 presents probit regression results. Column 2 presents deprobit coefficients for key independent variables. The corrected marginal effect of a change in two interacted variables for probit model is presented in the curly bracket. 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 7. Incorporation is an indicator variable for the state (country) where a US (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. Please refer to Table 7 for the definitions of other variables. Standard errors in the brackets are clustered at firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)
	Probit		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			
Adj R^2			0.19	0.23

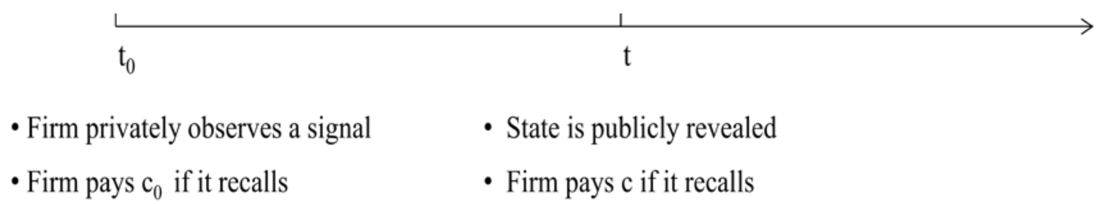
Table 7. Effect of Regulatory Monitoring on Recall Delay: Complaint Sample

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 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 with 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 where 100 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, respectively. Ln (Interval) is the logarithm of Interval as defined in Table 7. Incorporation is an indicator variable for the state (country) where a US (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. Please refer to Table 7 for the definitions of other variables. Standard errors in the brackets are clustered at firm-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

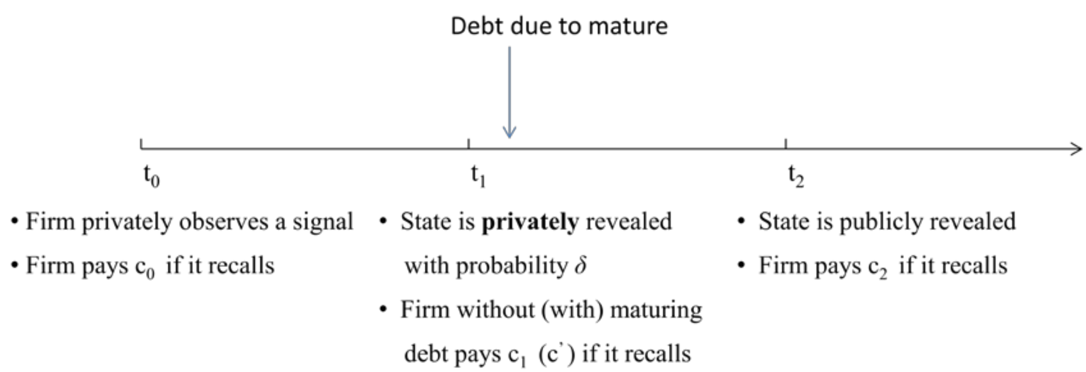
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
State has NHTSA Regional Office	Yes		No		Yes	No	Yes	No
	Probit		Probit		OLS	OLS	OLS	OLS
Maturing Debt	-29.79***	-0.16	12.71**	3.33	0.11	4.86***	-3.89	3.36
	(8.78)		(5.41)		(2.36)	(1.43)	(5.40)	(2.99)
Maturing Debt*Density75	-17.88	-0.10	-12.71	-3.33	-0.06	-2.92	0.55	-3.69*
	(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					
Adj R^2					0.22	0.12	0.17	0.09
In Region 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 Pro-Active Regulator)



Panel C: Pre-TREAD Period (Three Dates, More Pro-Active Regulator)

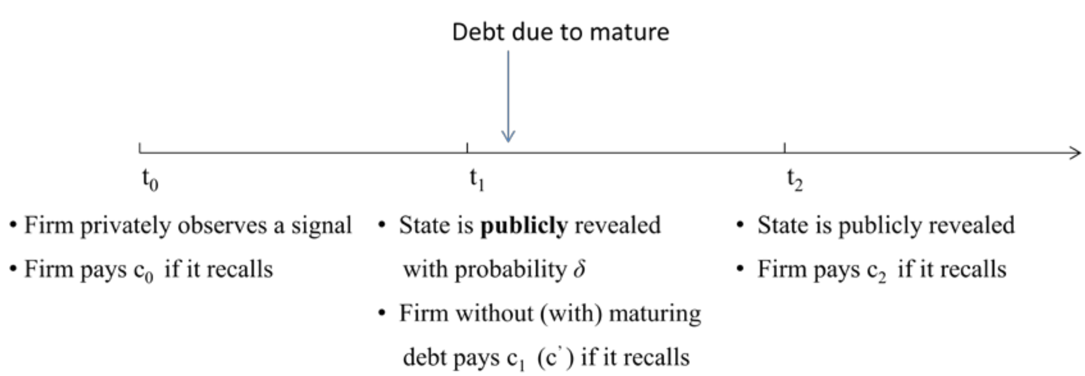
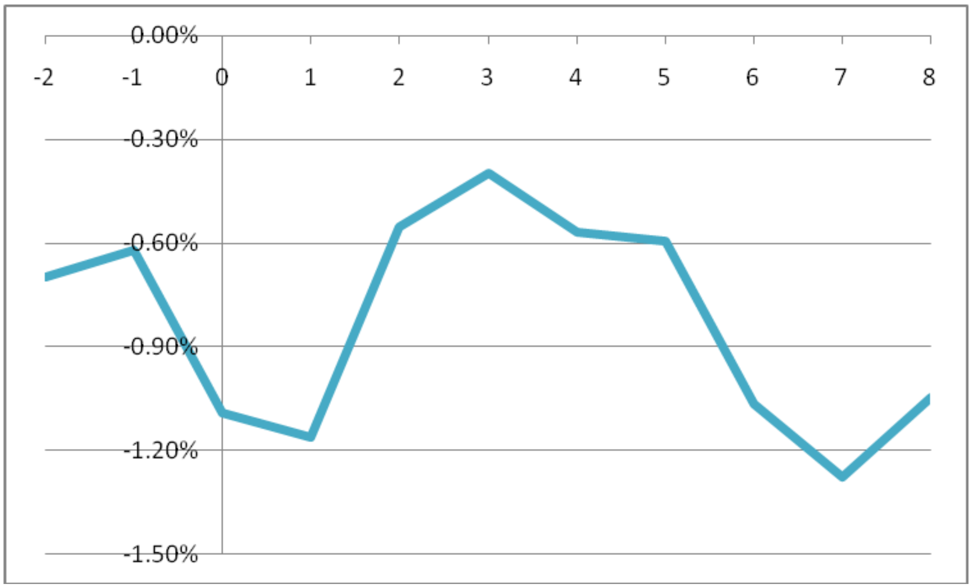


Figure 2. Quarterly Sales Growth around Recall Events

The sample consists of firm-quarter observations for voluntary recalls by public vehicle manufacturers from January 1966- July 2010. The vertical axis represents quarterly sales growth adjusted by 3-digit SIC industry median. The horizontal axis represents event time, which is zero in the quarter in which recalls occur. QRatio is the aggregated # of units affected by the firm's recall in a given quarter scaled by total # 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 cutoff.

Panel A: Ratio >50th



Panel B: Ratio>75th

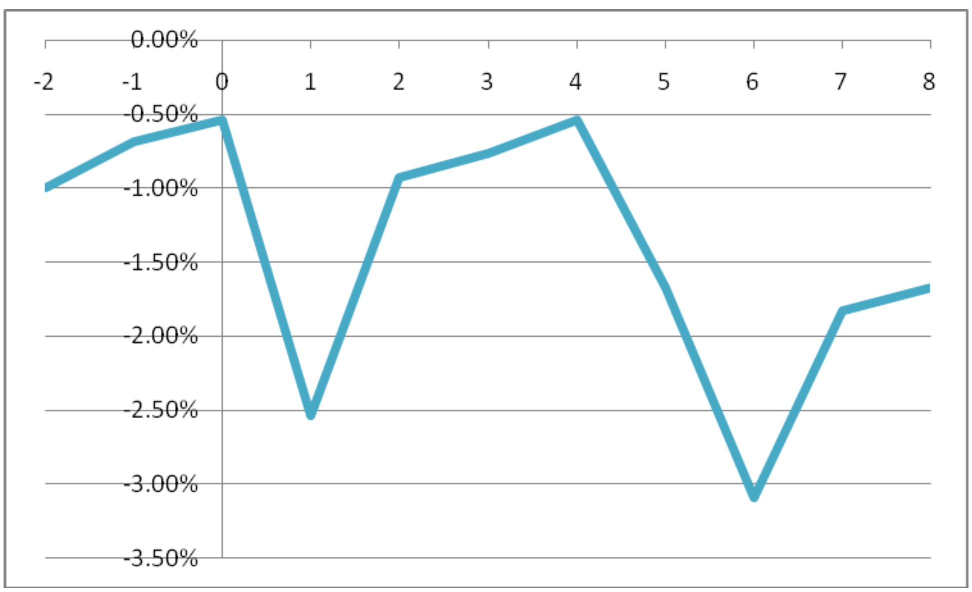
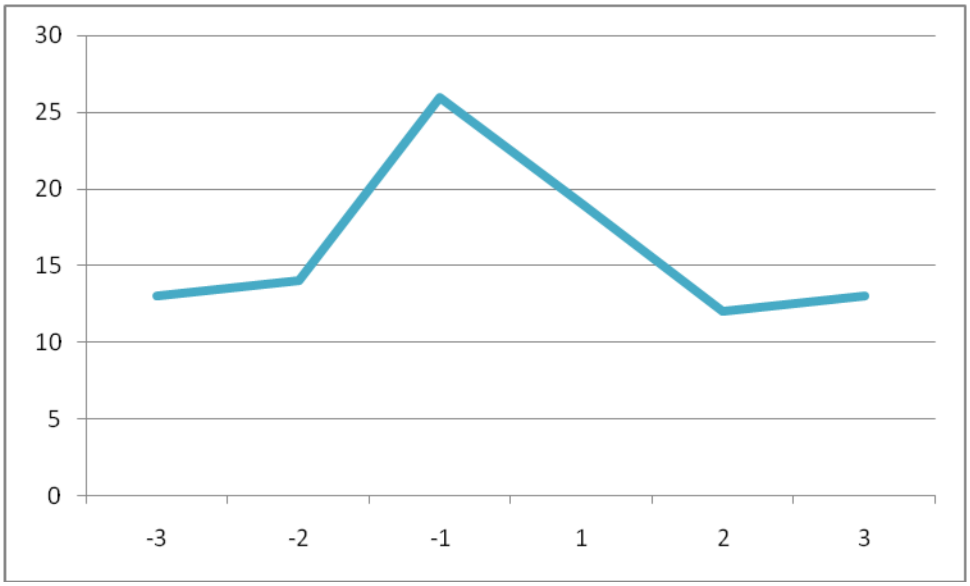


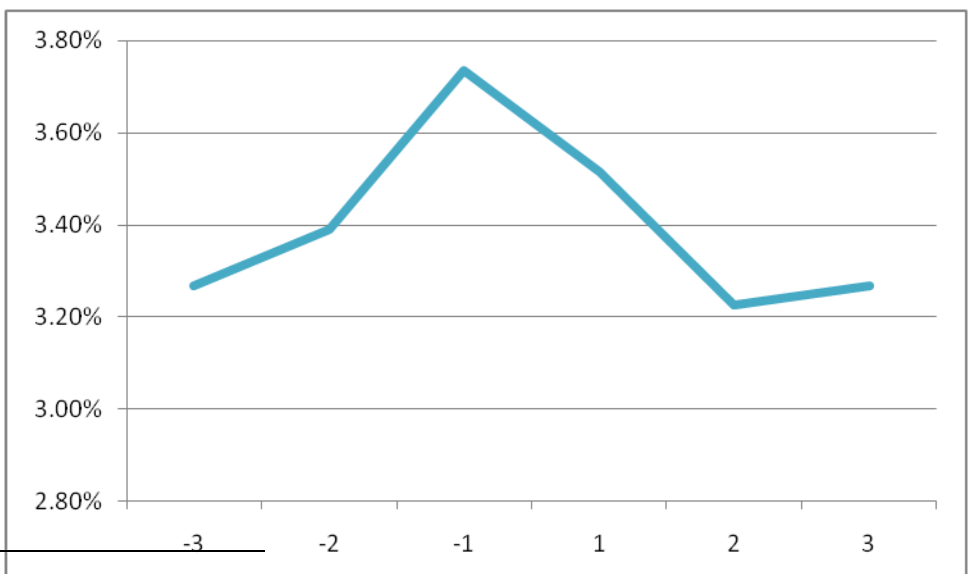
Figure 3. Issuances around Recall Events: Ratio>50th

The issuance sample consists of firm-month observations for public vehicle manufacturers that issued debt or equity from January 1970- July 2010**.** Ratio is the # of units affected by the firm's recall scaled by total # 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 NHTSA. 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 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.

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

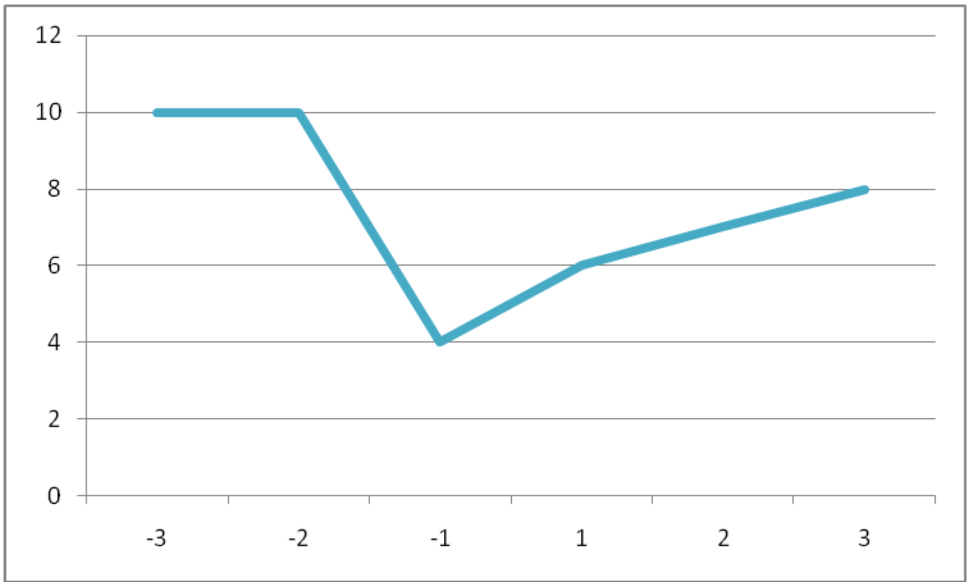


Panel B: Median of Issue Amount around Firm-Initiated Recalls



* 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 C: # of Issues around Government-Initiated Recalls



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

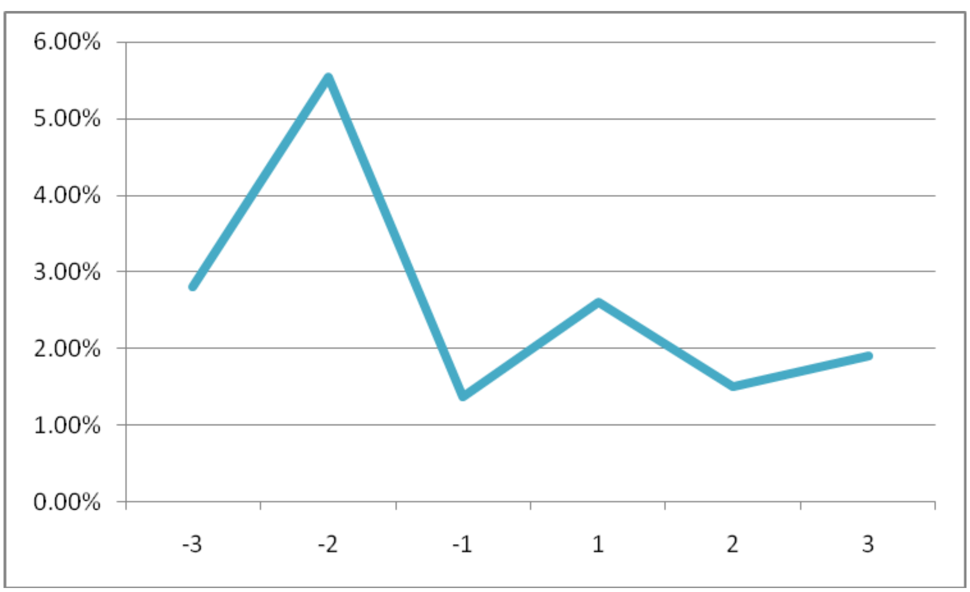
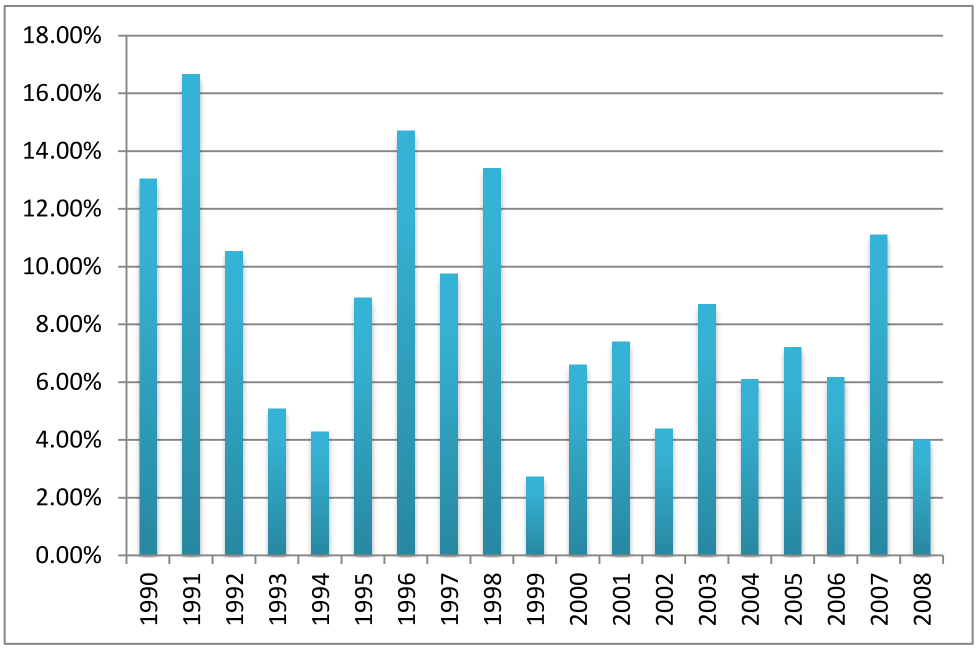


Figure 4. Regulatory Proactivity

This chart shows the average ratio of number of recalls subject to NHTSA investigation over total number of recalls initialed by the manufacturer or the government for all vehicle manufacturers for each year. Only recalls initiated within 800 days after the beginning of manufacturing and with above-median Ratio are included. Ratio is the # of units affected by the firm's recall scaled by total # of employee as of the fiscal beginning of the year. Pre-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

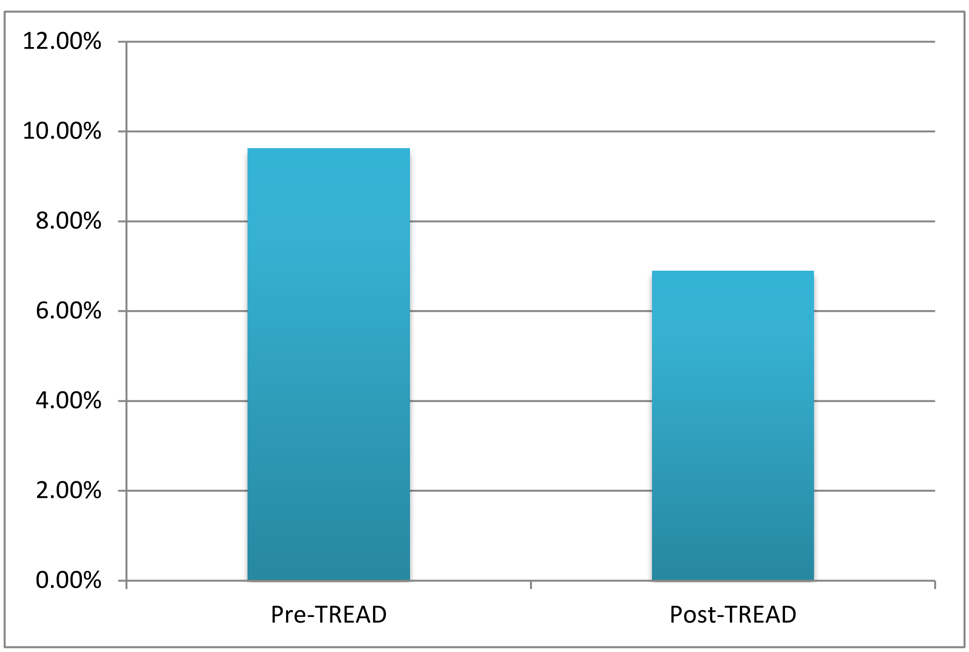
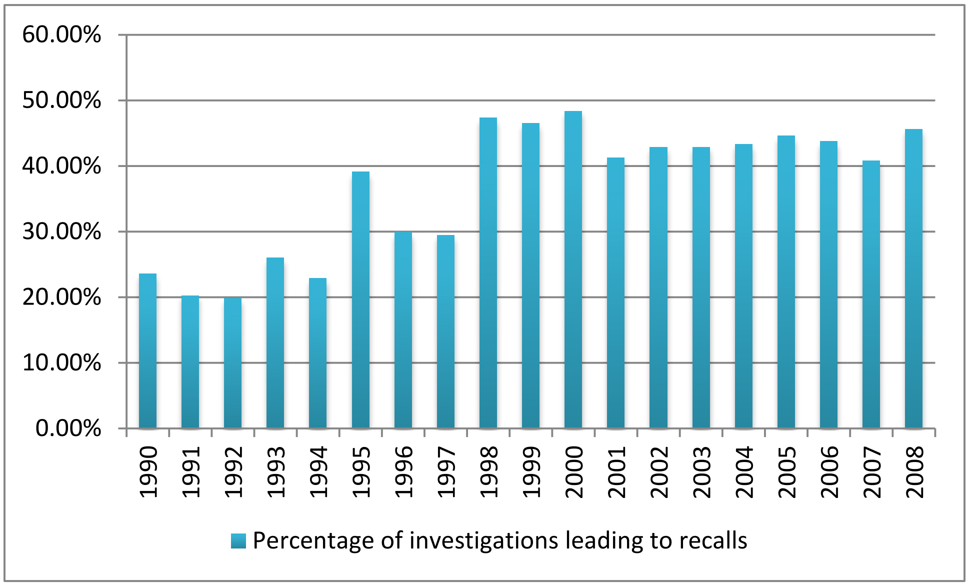


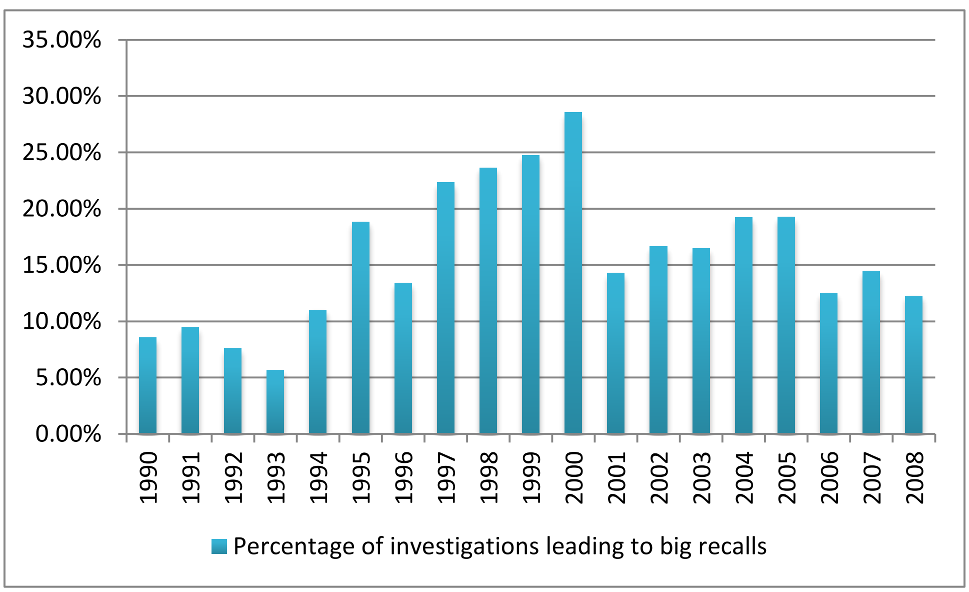
Figure 5. Defect Investigations Leading to Recalls

This chart shows the fraction of defect investigations initialed by NHTSA 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 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

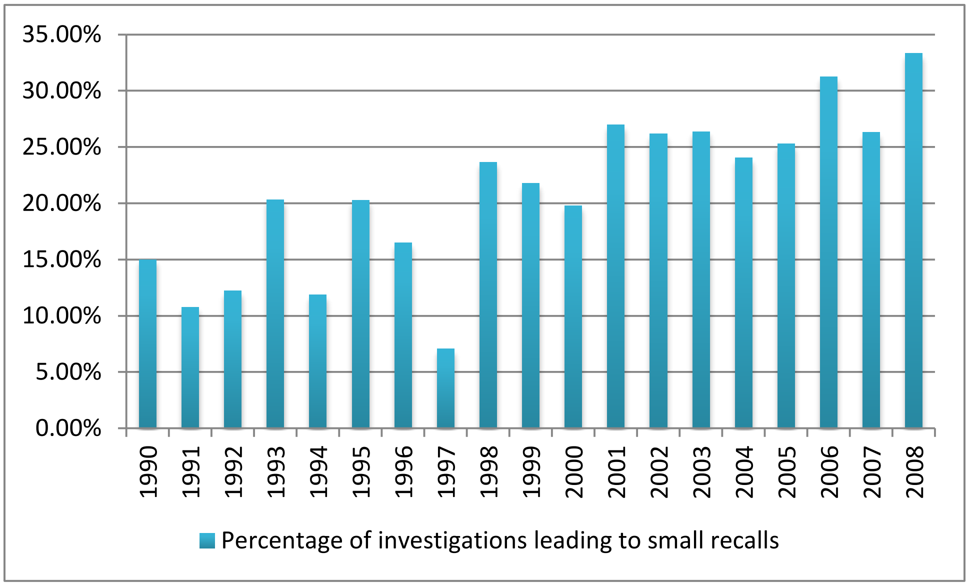


Figure 6. Durations of Defect Investigation

This chart shows the duration of defect investigations initialed by NHTSA each year. Duration is measured as the number of days from the opening to the closing of the investigation.

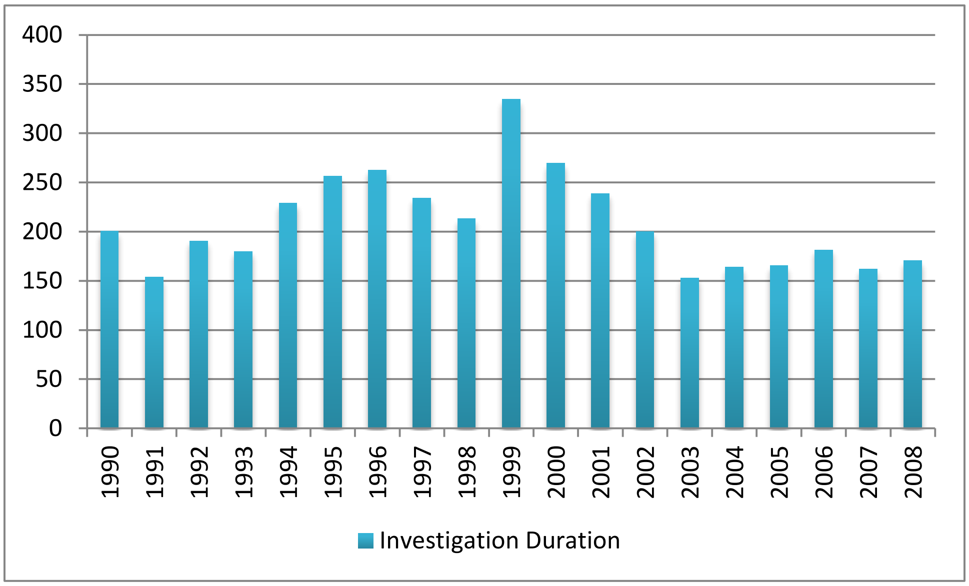
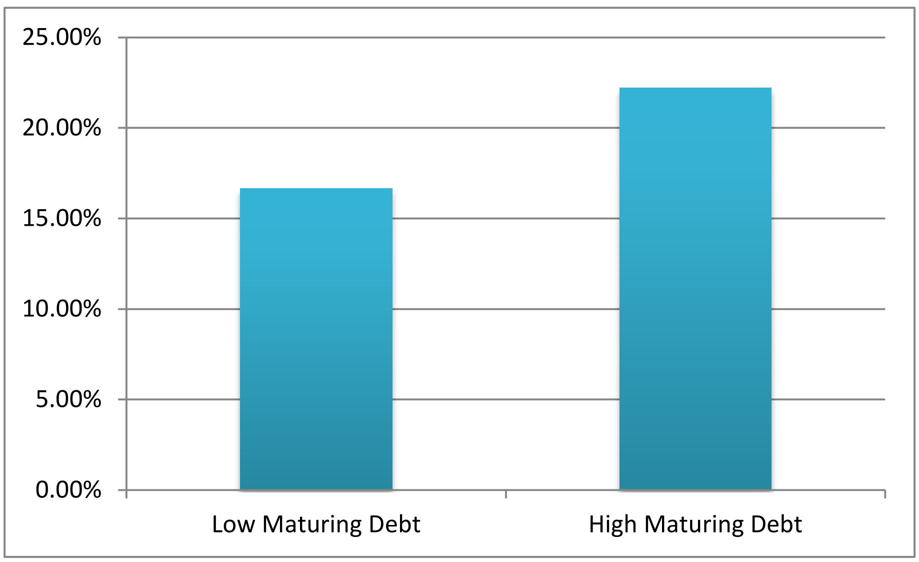


Figure 7. Maturing Debt and Early Recalls

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 the passage of the TREAD Act. 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 100 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 the following criteria: (a) For both recall campaigns, manufacturing starts in the same calendar month (to control for the time interval between start of manufacturing and the 100 days from fiscal year end cutoff) (b) Both recalls are initialed by the same firm (to control for firm-specific effects). Since the second criteria requires that the two recalls must 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