Information Transmission and Vehicle Recalls: The Role and Regulation of Recall Notification Letters

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Abstract

Using data on correction rates for vehicle recalls in the United States from 2007 to 2010, we investigate information transmission from manufacturers to owners regarding the defects of recalled vehicles. We pay special attention to the role of the language manufacturers use to convey each recall's seriousness in the letters they send to owners to explain the nature of the defects in their vehicles, and the possible consequences if the defects are not fixed. We find that recalls linked to riskier defects, defined by the type of equipment affected in the vehicles, are associated with higher correction rates. Interestingly, the content of recall notification letters plays an important role in increasing correction rates because the letters convey information to owners above and beyond baseline information about which part of their vehicles can present problems. We also find that, in a number of cases, the language that manufacturers use to explain the risks to owners are worryingly milder than the descriptions the National Highway Traffic Safety Administration (NHTSA) use, resulting in significantly lower correction rates. We conclude that information transmission to owners regarding recalls should be more clearly regulated since the language affects drivers' likelihood of taking their cars to be fixed. We advocate that the NHTSA return to the pre-2001 practice of assigning hazard levels to all recalls, and that the agency consider making sure manufacturers clearly communicate recall rating information to vehicle owners. Our results indicate that these practices would result in higher correction rates, remove faulty cars from the roads, and, consequently, save lives.

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1. Introduction

The number of automobile recalls in the United States has substantially increased over the last two decades, and in 2012 alone, more than 17.8 million vehicles were recalled. Vehicle recalls and safety are now drawing more public attention than ever, but, in spite of the increased public concern about recalls, there has been few empirical studies on the relationship between recalls and safety. Most studies discuss particular aspects of recalls, such as their effects on demand, vehicle resale prices, firm valuation, liability verdicts, or recall initiation, but not safety.[1] More recently, Bae and Benítez-Silva (2011 & 2013) directly tackled the safety issue and found that recalls are effective in reducing the number of accidents as well as injury severity. They also found that vehicle models with recalls with higher correction rates have, on average, fewer accidents in the years following a recall. They have concluded that recall regulation is "effective" in the sense that removing defects reduces accident damage on the roads.[2]

The process that can make a recall campaign effective, requires active cooperation of all related parties: regulators, vehicle manufacturers, and vehicle owners. The NHTSA requires that vehicle manufacturers notify recalls to their customers via First-Class Mail so that vehicle owners can take their vehicles to dealers. Then, dealers remove defects from the vehicles at no cost to owners. Even if both regulators and manufacturers issue recalls in a timely manner, recalls will not be effective if vehicle owners do not take their vehicles to dealers, because potentially risky vehicles will still be on the road. Therefore, vehicle-owner efforts are essential to completing successful recall campaigns. The corrective action can be measured by the correction rate, which is the ratio of the total number of items inspected and remedied to the total number of items involved in a recall.[3] Therefore, raising the correction rate implies that the number of vehicles with potential defects which are still on the road are reduced. Raising the correction rate from the current average levels of around 70%, to a higher level would result in more "effective" recall campaigns. Therefore, the NHTSA prioritizes working closely with manufacturers to raise

[1]These papers include Crafton, Hoffer, and Reilly (1981), Jarrell and Peltzman (1985), Hartman (1987), Huble and Arndt (1996), Marino (1997), Rupp and Taylor (2002), Rhee and Haunschild (2003), and Bates et al. (2007).

[2]It is hard to conclude, however, that the regulation is "cost-effective" because a careful cost-benefit analysis would include valuing human lives and human suffering and without detailed information on the injuries and the characteristics of those involved in the accidents that exercise would be quite speculative.

[3]The total number of items inspected and remedied includes the total number inspected and not requiring remedy.

correction rates. However, it is not possible to raise the correction rate to 100 percent because vehicle owner decisions depend on many factors, including personal preferences, constraints in terms of time and resources, and the recall information available to them.[4]

Carefully using the detailed information in our data set, and paying special attention to the role of letters sent to owners, we identify the factors that affect the likelihood of owners choosing to respond to recalls. We are the first researchers to analyze the letters sent to vehicle owners, and we do so one by one for all the vehicle recalls we use in our estimation.[5] We find that recalls with riskier defects are associated with higher correction rates, and that owners of certain brands and newer year-models respond more actively to vehicle recalls. One of our key findings is that the language used in recall notification letters plays an important role in increasing correction rates, even after controlling for a measure of hazardous defects.[6] If the letter includes alerting phrases or words, such as "death," then the corresponding recall's correction rate is 10% higher than letters without such phrases, and the relationship is statistically significant. We suggest that vehicle manufacturers initiate recalls as quickly as possible once serious defects are found, and that recall notification letters contain more detailed information on risks so that the owners can correctly evaluate them.

We also find, in a number of cases, worrying disparities in the language the NHTSA uses on its website to describe the consequences of certain defects and the language manufacturers use to explain the very same defects to owners, eventhough in a majority of the cases no disparities are observed. Our estimates show that the presence of these disparities is negatively correlated with correction rates, indicating that the lack of appropriate language in the letters lowers correction

[4]Notice that some non-obvious factors can end up affecting the success of a recall campaign. For instance, some large recalls may affect the correction rates of other recalls because of the publicity and notoriety they receive, and indirectly affect the owners' perception of the risks of all recalls. We will also try to control for this type of effects.

[5]Hoffer, Pruitt, and Reilly (1994) also try to explain the factors that affect correction rates. Their study found that owner response rates are higher for owners of American vehicles, newer vehicle models, and vehicles with severe safety-related defects. However, their model specification is problematic since there are plenty of variables that they do not include, biasing the coefficients of interest, and they do not take into account the role of the letters from manufacturers to owners in their analysis, which we believe is key to understand how individuals assess risk and decide to act, and to understand the role of the regulator to guide the dissemination of safety information to owners.

[6]Recall notification letters are also used in other industries, for example the medical devices industry that depends on the FDA. As briefly discussed by Hoffman (2013) the lack of regulation by the FDA of those letters also opens the debate about their effectiveness and the proper way to disseminate information about recalls to the public. Our empirical study can be considered a pioneer in the analysis of information transmission about recalls.

rates. We advocate for the NHTSA to return to their pre-2001 practice of giving all recalls a hazard rating, and to consider requiring that manufacturers include this hazard rating in letters to vehicle owners.

The rest of the paper is structured as follows. The next section presents the process of U.S. recall campaigns, and discusses owners' likelihood of responding to recalls and the potential risks they face from not doing so. Section 3 discusses the recall data and the sample construction. The estimation strategy, the econometric model, and the summary statistics of the data we use are discussed in section 4. Section 5 discusses our estimation results. Concluding remarks and a discussion of the policy implications of our work are presented in the final section.

2. Vehicle Recalls, Correction Rates, and Information Transmission

2.1 The Recall Process and the Correction Rate

The recall system for motor vehicles in the United States was first introduced in 1966 to improve public safety by removing potentially harmful defects from cars sold in the U.S. Since then, the NHTSA and manufacturers have issued more than 15,063 recalls, and the campaigns have become more active in recent years.[7] The entire recall process is quite lengthy.[8] A recall is issued by either the manufacturer or the NHTSA when a motor vehicle or item of motor vehicle equipment (including tires) does not comply with a Federal Motor Vehicle Safety Standard. The recall is also issued when a safety-related defect is found in the vehicle or equipment. Once the recall is issued, manufacturers report to the NHTSA the details of their action, and the agency also reviews the recall notification letters, which are then mailed to owners of the recalled vehicles.

For each recall, the NHTSA requests that the manufacturer reports its correction rate to the agency for 6 quarters following the date the recall is issued. The correction rate is included in the quarterly status report. Each report should include (1) The notification campaign number

[7]Between 2000 and 2009, manufacturers of motor vehicles and vehicle equipment conducted almost 6,300 recalls to address safety issues ranging from malfunctioning airbags to defective child safety seats (GAO, 2011).

[8]For more details, see Bae and Benítez-Silva (2011 & 2013), and as an example the recent news about a recall of 1.56 million vehicles by Chrysler of vehicles built in the mid-90s and early 00s, discussed in Vellequette (2013).

assigned by the NHTSA; (2) The date notification began and the date notification ended; (3) The number of vehicles or items of equipment involved in the notification campaign; (4) The number of vehicles and equipment items that have been inspected and repaired, and the number of vehicles and equipment items inspected and determined not to need repair; and (5) The number of vehicles or items of equipment determined to be unreachable for inspection due to export, theft, scrapping, failure to receive notification, or other reasons Some manufacturers send follow-up notifications beyond the first 18 months of a recall campaign even though the NHTSA does not require them to do so.[9] According to the Report to Congressional Requesters, the average correction rate is about 70%.[10] However, the correction rates vary within a range of 0.1% and 99%.

There is a number of reasons why the correction rate is not likely to be 100%. First, not all notification letters reach the vehicle owners. In particular, if the owners of recalled vehicles changes or owner addresses change, then the letters cannot reach owners. Used car owners have a higher probability of not receiving the letters. Second, some vehicle owners do not respond to the letters even if they receive them. This is mainly because some owners may believe that the defects might be minor, or they may consider the time-costs of fixing the vehicles greater than the benefits of doing so.

One intuitive measure of the success of recall campaigns is the existence of a positive relationship between the correction rate of a recall and the level of risk of the defects of the vehicles in that campaign. If this relationship exists, we can conclude that there must be something that conveys the information on risks from manufacturers to owners, or owners have other ways of acquiring that information. There are three ways vehicle owners to obtain information about the defects. The first one is the recall notification letter. The second one is an announcement through the NHTSA website. The last one is newspaper and online coverage of the campaign. The first method is formal and direct, while the second method cannot be effective unless vehicle owners actively seek possible vehicle recalls from the NHTSA's website. The third method is independent of manufacturers' decisions on recall announcements. The media deals only with recalls that may attract public interest.[11] In particular, if there are large recalls or recalls that

[9] GAO (2011).

[10] Data from 2000 and 2008 on passenger vehicles,(GAO, 2011).

[11] Hoffer, Pruitt, and Reilly (1994) show that the correction rates are not associated with media coverage. However, their conclusion does not show clear evidence because media coverage in their study is

capture public attention, then vehicle owners in general may check to see if their own vehicles are also subject to recalls, even if their vehicles are not related with the big recalls or the recalls that are attracting public attention. This argument is tested in our paper. Therefore, the first method, the recall notification letter, most likely is the most important source of information that leads to owners' corrective behavior. The problem is whether or not the letters accurately reflect the risks. There might be a gap between the actual risk level and the perceived risk level. The perceived risk is the risk that vehicle owners evaluate for their recalled vehicles from various sources, including the letters. If the risks are substantially different, then the correction rates may not be proportional to the risk levels. If the perceived risk level is lower than the actual risk level, then raising correction rates of certain recalls may not necessarily help reduce the number of accidents, assuming that the defects with greater risk levels cause more serious accidents.[12]

2.2 Risks and Recall Notification Letters

Recalls can be split into two groups, hazardous and non-hazardous recalls.[13] Hazardous recalls may cause serious injuries or deaths if the defects cause accidents. Non-hazardous recalls are the recalls with relatively lower hazardous defects. Hazardous recalls include problems with wheels, vehicle speed control, engine and engine cooling, suspension, and steering. Around 60% of recalls used to receive the hazardous rating. Non-hazardous recalls include problems with seat belts, power trains, exterior lighting, structure, body, windshields, service brakes, equipment, and labels. Some non-hazardous recalls also include issues with steering, airbags and fuel systems. However, the ratings were determined by careful investigation from the NHTSA and manufacturers.

One problem with this rating is that there is no way for vehicle owners to know which rating their recall fits. They do not know this for two main reasons: (1) Since 2001, the NHTSA has stopped specifying hazardous or non-hazardous ratings for recalls. (2) The recall notification letter does not include a rating. Therefore, vehicle owners should evaluate the risk level from

defined by whether a press release was reported by the Wall Street Journal, and their result correspond to a pre-internet period.

[12] Bae and Benítez-Silva (2011) show that the correction rate is negatively associated with the number of accidents. However, they do not analyze what drives correction rates, and do not study the role of the notification letters.

[13] Risk in this context is probably better measure as a continuous variable, however, the NHTSA when rating recalls in the past used 4 categories, A, B, C, and D. Nowadays, they do not even release this information to the public.

the type of equipment involved in the recall and from language in the notification letters, or from other sources. In this case, the risks of a recall are perceived and evaluated by the owners. Currently, the manufacturers of the recalled vehicles do not have to announce recalls through the media, such as newspapers and news announcements, although they often are announced, especially if they affect a large number of vehicles.

If manufacturers follow the guidelines from the NHTSA, the letter should describe the safety defect of the recall and the consequences of the defect. The letter should also include an evaluation of the risk, a description of what a vehicle owner can do to get the defect remedied, a statement of precautions that the vehicle owner should take, if any, and the symptoms that will occur before the defect is repaired. The letter must clearly say that vehicle owners do not have to pay for the repair. The time costs of fixing defects may also affect owners' decision on whether they fix or delay the decision to take their vehicles to the dealers. For instance, there are two letters. One letter says, "The procedure will take approximately 30 minutes." The other letter says "It will take a day, but due to service scheduling, your retailer (or dealer) may require your vehicle for a longer period of time." The owners of the latter would tend to respond less because of the time cost. Manufacturers should include repair time measured in hours. However, this may not be a reasonable measure for consumers' time costs. Interestingly, among the recalls in the data set we use, the recall notification letters for 23 recalls do not clearly indicate repair time. Furthermore, even though the repair time is in the letter, it is difficult to quantify the repair time costs because of additional expressions. Language like, "Repair times will vary and depend on your dealer's appointment schedule," "Due to service scheduling, your dealer may require your vehicle for a longer period of time," and "Plan to leave your vehicle with the dealership to allow the dealer some flexibility for scheduling your repairs," can cause serious measurement errors. For our estimation, we will exclude this variable. In reality, the contents of the letters are highly discretionary, which means that it is entirely up to the manufacturers to determine how alarming the descriptions about risks and consequences are in the letter.

The risk levels are only explained in the letter's description of the defects. Therefore, the descriptions that show urgent or high-risk defects include: "could lead to a fire," "can increase the risk of injury for smaller drivers in a frontal crash," "can result in a crash without prior warning" or "could cause a crash resulting in injury or death." The use of words, like fire, urgent, immediate, crash without warning, injury, or death, may indicate the relative seriousness of the defects to vehicle owners. The lack of standardized language and ratings is clearly problematic, especially because it leaves the decision transmitting a sense of urgency regarding vehicular problems in the hands of manufacturers, the only ones who can benefit from low correction rates. This does not mean that manufacturers act necessarily in a malicious manner, in fact we find that in some cases the language they use is actually stronger than the one suggested by the NHTSA, but they understand that the safety of a particular motor vehicle at a particular point in time is a function of many variables, one of them the mechanical or technical issues of the vehicle. As cost minimizers, and entities that want to maintain a reputation for quality, they are the ones more likely to play down any issues that arise with their products unless the regulators is willing to step in and further clarify the information that needs to be included in the letters. We have created a set of variables to measure these discrepancies, and we will use them in our estimation to uncover the possible effect of this difference in information transmission on correction rates.

3. Recall Data and Sample Construction

We use recall data from the NHTSA containing recalls occurring from 2007 to 2010. The NHTSA updates recall data daily, and the data covers all recall campaigns from 1966 to the present.[14] We do not include recalls from 2011 or later because most recalls are ongoing and some reports have not yet been made.

Over the 4 years of study, 2,784 recalls were initiated. Table 1 shows summary statistics of these recalls. The table shows that 2,408 recalls are vehicle recalls. Other types of recalls include component, equipment and tire recalls. Their numbers are 33, 293, and 50, respectively. Thus, more than 85% of recalls are vehicle recalls. Either the NHTSA or manufacturers can initiate recalls, and manufacturers issue more than 70% of the vehicle recalls studied. The NHTSA's Office of Defects Investigation (ODI) and Office of Vehicle Safety Compliance (OVSC) mandated 645 recalls. Regarding yearly recall issuance, the number of recalls increases in 2008, decreases in 2009, and increases again in 2010. However, the total number of vehicles involved has increased

[14]For the data set, see "http://www-odi.nhtsa.dot.gov/recalls/".

since 2008. This implies that the recent recalls contain a much greater number of vehicles per recall.[15] Over the 4-year period we analyze, more than 61 million vehicles were recalled.

Table 2 shows the types of defects over the same period. The equipment recall is dominant and it consists of 33% of all categories of defects. Other major types of defects include service breaks, engine and engine cooling, steering, electrical systems, and fuel systems. The defects in child seat belts are all included in the equipment recall category. There are only 62 tire recalls. Among them, 12 recalls are included in the vehicle recall category.

Table 3 shows the number of vehicles included in these recalls. Sixty-four percent of the recalls can be considered small ones, since they include 1,000 or fewer vehicles. In terms of the number of vehicles, all these recalls add up to less than 1% of the total number of vehicles included in all recalls. More than 500 recalls include between 1,000 and 10,000 vehicles, while 257 recalls include between 10,000 and 100,000. There are 114 recalls with more than 100,000 vehicles. However, these larger recalls cover 80% of the total number of vehicles involved in all recalls over the four years studied. Furthermore, there are 11 mega recalls, which involve 21 million vehicles in total, so about 38% of the recalled vehicles come from these 11 recall campaigns. Thus, the distribution of the number of vehicles per recall is extremely skewed.

From these recalls, we remove recalls that do not meet our research criteria and end up with 178 recalls. The selection criteria are as follows.

First, we drop non-vehicle recalls from our data set. Most defective equipments and tires are equipped across many vehicle models. Some tires are installed in different models produced by different manufacturers. Therefore, the data from these recalls are not suitable for the purpose of our analysis. Furthermore, a substantial portion of recall data on year models are unknown, so we only include vehicle recalls, which drops 376 recalls from the data.

Second, we drop recalls with fewer than 1,000 units. There are 1,523 recalls in this category, seemingly substantial. However, as we mentioned earlier, these recalls amount to about 0.5% of the total number of recalled vehicles over the four years studied. Furthermore, some recalls contain only, say, 10 vehicles. In this case, the correction rate is not very meaningful. Some manufacturers locally produce their vehicles, so their correction rates may not correctly

[15]Toyota began to issue accelerator related recalls, beginning in the fall of 2009. The first large-scale recall issuance began on November 02, 2009 and 4.4 million Toyota and Lexus vehicles were recalled. Since the Toyota recall concentrated the public attention, other recalls did not receive as much coverage, but Ford also recalled its 4.5 million trucks that fall.

represent the whole population.[16]

Third, we also drop recalls involving current year-models because many vehicles are still in the inventory of the dealers or being manufactured. These vehicles affect correction rates and the resulting correction rates are not determined by owners' corrective behavior. Hoffer, Pruitt, and Reilly (1994) also drop these recalls because of the same reason. In our case this results in dropping 409 recalls from the data.

Fourth, in the case that same defective parts or items are included across different types of vehicles, we cannot use this data because we control for vehicle types. For instance, a recall can be issued because of the defects in an item assembled in different vehicle-model categories, that is, the same item is equipped in both trucks and compact cars. We remove these multi-vehicle recalls because our estimation controls for vehicle types, but if a recall is issued for vehicle models within the same category, then we include the recall. For example, suppose that a defective item in a Ford recall is in both F-250 and F-350. Both types are trucks, so we include the recall in the data set. Also, a few recalls were dropped because of incomplete data. Overall, we drop another 298 recalls, leaving our estimation data set with 178 recalls.

In terms of the number of recalled vehicles, about 21.6% of the recalled vehicles are included in the data set. Our exclusions might seem rigorous, but given the detailed information we analyze for each recall, which requires reviewing by hand several documents of several pages for each observation, it is understandable, we believe, that we can only keep the observations that have complete, quality information.

4. Analysis and Estimation of Correction Rates

The data we use contain detailed information on each recall. Each recall also includes a variety of recall-related documents, which we analyze one by one. We use Quarterly Performance Reports to calculate the correction rates, which are then used as a dependent variable in our model. For each recall, there are 6 correction rates.[17] In our cross-sectional model, we use the fourth-quarter

[16]One alternative way to solve this problem is to calculate the weighted correction rate. This means that we put more weight into the correction rate, according to the number of recalled vehicles included. However, we have decided not to follow this possibility given the very small number of vehicles included in this exclusion criteria.

[17]The correction rate is no longer available in the data set. Thus, we manually calculated them from the quarterly reports.

correction rate. Since there are 6 quarterly reports for each recall, we use them in a panel data model to get a dynamic picture of the correction rates.

In terms of the specifications we present, first, we check to see if the recall campaigns we analyze play an effective role in removing more serious defects from the road at a higher rate (Model 1). If we find that the correction rates are higher when recalls include more hazardous defects, then we can conclude that the current recall campaign is effectively removing more serious defective items at a higher rate. To accomplish this, we include a variable, $RISK$, which, as explained below, is a constructed variable as a function of the type of vehicle equipment affected by the recall, using our knowledge about how the distinction between different types of recalls was decided by the NHTSA years ago. This can be thought as a possible summary measure, which if uncorrelated with correction rates would suggest a major failure of the recall system. This specification does not investigate how this information is actually acquired by individuals, even if we suspect that the main source of information is the letter sent by manufacturers which includes the equipment affected by the recall. This is clearly a potentially noisy measure of the actual risk to the owner since it is just a binary indicator and does not include the level of seriousness of the defect, just which part of the vehicle is affected. Notice that we cannot directly observe how or whether vehicle owners receive defect information, or how they form their perception of the risk, but we suspect that a high proportion of those who receive the letters will read them and at least check what kind of recall (which equipment is involved in the recall) they are suppose to respond to.

This specification is directly comparable (up to some degree, given the different time periods use and the fact that we include additional controls even in the simpler specification) with the results presented in Hoffer, Pruitt, and Reilly (1994). However, given our detailed analysis of the data we can go much further than those authors and analyze if the kind of equipment involved is all that matters or more information is extracted by individuals from the information they acquire about the recalls, mainly through the letters.

Second, we test to see if the language in the recall letters sent by manufacturers can be linked with owners' corrective actions instead or on top of the constructed measure of the risk of the recall (Models 2 & 3). If the language in letters fully and correctly reflects corresponding risk levels and captures the same information as just the type of vehicle equipment affected, then it would not be necessary to include the constructed risk variable in the estimation model, and it would suggest that the language in the letters is basically the only measure of information that individuals process. The three specifications follow.

$$\text{[Model 1]} \qquad y_i = \alpha + \beta_1 RISK_i + X'_{2i}\beta_3 + \epsilon, \qquad i = 1, ..., 178.$$
$$\text{[Model 2]} \qquad y_i = \alpha + X'_{1i}\beta_2 + X'_{2i}\beta_3 + \beta_4 DIFF\_MILD_i + \epsilon, \qquad i = 1, ..., 178.$$
$$\text{[Model 3]} \qquad y_i = \alpha + \beta_1 RISK_i + X'_{1i}\beta_2 + X'_{2i}\beta_3 + \beta_4 DIFF\_MILD_i + \epsilon, \qquad i = 1, ..., 178.$$

$RISK$ is the dummy variable that indicates whether the recall is a hazardous recall. X_{2i} are other control variables that reflect vehicle and manufacturer characteristics. We give $RISK$ the value 1 if a recall is a hazardous recall - associated with problems in wheels, vehicle speed control, engine and engine cooling, suspension, or steering. Otherwise, it is a non-hazardous recall. Since the information on hazard ratings is not directly available, we have followed the practice in place up to 2001 when the ratings were published by the NHTSA. While some misclassification is possible, we believe the variable represents well, on average, the overall risk to the owners. Without identifying how the information on potential risks is conveyed to vehicle owners, we can still test to see if the information is correctly conveyed in terms of affecting the correction rates. Model 1 tries to accomplish the latter and get at the point of whether more serious recalls do get fixed more often.

Model 2 drops the constructed indicator of the seriousness of the recall, $RISK$, and instead includes a vector of variables, X_{1i} that try to measure the level of risk conveyed in the recall notification letters, independent of whether the equipment involved already captures the seriousness of the recall. If the risks are well-reflected in the letter language, meaning there is a strong correlation between the type of equipment involved and the way the letter conveys the risk to the owners, then Model 2 would show very similar results to Model 1, with the new variables playing the role of the constructed $RISK$ variable, and with very similar estimates for the rest of the variables of interest, and similar model fit. We also include the $DIFF\_MILD$ variable as an additional control, trying to capture whether the discrepancy (in this case phrasing in a milder way) between the language in the letters and the language in the NHTSA description of the consequences of the faulty equipment, affects correction rates.

Model 3 is then used to assess whether the information in the letters adds to information on the constructed risk measure, suggesting that is not enough to know the type of equipment involved but also whether there is a more serious issue involving that equipment. So we include both types of information in the specifications of Model 3, along as well to the measure of the discrepancy in the language of the letters. If the different types of measures are statistically significant, that will indicate that while the affected equipment matters, owners also pay attention to information regarding the risk to them derived from the possible failure of that equipment. Under this condition, and depending on how the estimated coefficients change, we will be able to understand the role played by each letter's language, which is very important because it is the less regulated aspect of information transmission between manufacturers and owners. Suppose that there are two recalls. One for engine defects and the other for windshields. Correction rates for each recall would probably differ because of the different average risk levels associated with defects in engines and windshields. We can probably expect the correction rate for the engine defects to be higher. However, the language in the recall notification letters could add information to convey how serious the recalls are, after controlling for the equipment type effect. If that is the case, it suggests we should pay more attention to how information reaches owners.

4.1. Recall Notification Letters

To see the effects of the recall letter on the correction rate, we create four variables from each of the letters in increasing level of seriousness of the consequences resulting from the faulty equipment. They are *CRASH*, *CR_IN*, *CR_IN_DE*, and *DEATH*. The first variable, *CRASH*, is a dummy variable that takes the value 1 if the letters include the phrase, "Vehicle crash without warning", otherwise, the value is zero. We use this variable to see if vehicle owners who receive letters with this expression take, on average, higher corrective actions after reading the letter with that phrase. This first variable is the weakest criterion, so we expect it to have the smallest effect on the correction rates. Next, the variable, *CR_IN*, includes either "Results in injury" or "Vehicle crash without warning," so it is a more serious risk to the owner, and we expect a larger effect on correction rates. The third variable, *CR_IN_DE*, considers the cases in which an additional word, "death," is added to the previous two phrases. Finally, the variable *DEATH* includes those recalls in which the letters only include the word, "death." These are the key independent variables that try to capture the effects of the language included in the recall notification letters. Notice that the phrases may not, however, reflect actual risk levels correctly because the language is used at each manufacturer's discretion. For instance, a letter for a very risky recall may include only the word, "crash." Owners form their perceived risk by the letter, so if the letter includes "death," and the variable is positively and significantly associated with the correction rate, then we can conclude that owners have internalized the warning correctly, once we control for the objective baseline measure of risk of the recall.

We estimate both the second and the third models, using these four variables in succession to see the effect of increasing the level of seriousness conveyed to the owners on correction rates, with or without the control for the baseline effect of the type of equipment involved, and in all cases including the measure of discrepancy, towards milder language, between the language in the letters and the NHTSA report.

4.2. Other Control Variables

To control for vehicle and manufacturer characteristics, we include the following controls in our specifications:

(1) Dummy variables for the vehicle category - We divide vehicles according to the following types: compact, sedan, SUV, truck, and motorcycle. Buses are included in the truck category. If a recall is issued in more than one type, then we drop the recall in the data set because it is not possible to control for the vehicle type. The car classifications are from the Annual Consumer Guide for Automobiles. Subcompact cars are in the category of compact cars. Both midsize and large cars are included in sedan. Both minivans and buses are in the pickup truck category. Two special groups of cars are sports and import luxury. We slightly modified this classification so that sports cars are in either compact or sedans. We do not specify import luxury, but luxury cars are controlled by another variable. One thing to note is that we include motorcycles. Even though motorcycles are not included in passenger vehicle type categories, we include them because many recalls are issued for motorcycles. The consumer guide classes are somewhat closer to public perceptions, depending more on price and weight. (For more details, see Ross and Wenzel, 2002)

(2) Luxury vehicles - This is a dummy variable. A luxury vehicle is by definition more expensive than other vehicles, and therefore, once a recall is issued, owners may respond to it more actively than the owners of less expensive vehicles.

(3) Recreational vehicles - Recreational Vehicles (RV) are mainly included in the bus category. However, we believe that owners of recreational vehicles may behave differently, not respond to recalls as quickly, and have lower correction rates, because these vehicles are mainly non-commercial and not used on a daily basis.

(4) Foreign vs. Domestic - Nowadays, the distinction between domestic and foreign vehicles is less clear because of frequent mergers and acquisitions and the presence of foreign manufacturer plants in the United States. Foreign makers also have similar distribution channels to domestic car makers. However, we still want to test to see if this affects corrective behavior.

(5) Vehicle's age - This variable measures how old the vehicle is at the time of the recall issuance. To calculate this, we subtract the model year from the recall year. For instance, suppose that a recall for 2007 Ford Mustang is issued on May 2010. Then, the value of the variable is three. In many cases, recalls are issued for more than one-year models. In this case, we use the latest year model as the model year.[18] Owners of older vehicles may have a lower willingness to fix their vehicles, possibly because of the lower value of the vehicles themselves. Also, identifying current mailing addresses for older vehicles is very difficult if there have been multiple changes in ownership.[19] To measure a possible non-linear relationship between the age variable and the dependent variable, we also include the squared term of this variable.

(6) Unreachable Vehicles - Vehicle manufacturers should also report the number of the recall notification letters that are not delivered to the owners. These unreachable letters do not affect owners' corrective behavior. Therefore, we expect that the higher the ratio of the unreachable

[18]A possible way is to calculate the average model year, defined by the median value. However, doing so does not alter the estimation results in any significant way.

[19]The NHTSA has not conducted any formal analysis to confirm this. We believe that there are more ownership changes, on average, for older vehicles.

letters to the total letters is, the lower the correction rate is. There are many reasons why owners may be unreachable. These reasons include vehicles being undelivered, exported, stolen, or scrapped.[20]

(7) Big recalls - We observe if there was a big recall over a particular quarter. We define the big recall as recall involving more than one million vehicles. Recalling a million vehicles is not common, so these recalls may have a greater probability of being covered in the media, and the probability of vehicle owners seeing this piece of news will be higher. If these big recalls affect correction rates, we can conclude that recall letters are not the only channel through which owners receive recall information.

(8) Duration - This is the difference between the date of owner notification and the date of the first quarterly report. Each quarterly report shows its correction rate collected until the last date of each quarter, so this variable is very important to control for the difference in the dates. Suppose that a manufacturer notifies vehicle owners of a recall on March. 1. Then, the first correction rate reflects 30 days of corrective actions. Suppose that another recall's notification date is March 31. Then, the correction rate would be zero for the quarter. We need to control for this difference in days. The longer the duration, the higher the rate is in a fairly mechanical fashion.

(9) Manufacturers - Owners are heterogeneous in terms of their preferences on vehicle manufacturers. In order to control for this heterogeneity, we include manufacturer dummies.

4.3. Panel Data Model of Correction Rates

Each recall is announced at a particular time. Thus, all recalls begin their repair over different time periods. Manufacturers should report their correction rates at least six times. Therefore, the correction rates are different across different recalls as well as over time. To understand the dynamic aspects of recalls, a panel data model can be used. We use a modified random trend

[20] Some manufacturers report the numbers in each category, while many other manufacturers just report the total number of unreachable vehicles. Because of this data problem, we use the total numbers, regardless the reasons.

panel data model which can account for unobserved recall heterogeneity not correlated with the other independent variables.

$$y_{it} = c_i + T_t^{'} g + \beta_1 x_{it} + X_i^{\prime} \beta_2 + \epsilon_{it}$$

, where $T_t = [t \quad t^2 \quad t^3]$ and $g = [g_1 \quad g_2 \quad g_3]$. The dependent variable, y_{it}, is a correction rate of a recall, i, at the quarter, t. Independent variables consist of three components.

The correction rate of a recall increases as time goes by. To control for a possible non-linear trend, we use the polynomial terms. So if $\hat{g_1} > 0$, $\hat{g_2} < 0$, and $\hat{g_3} > 0$ and they are statistically significant, then we can conclude that the correction rates show a similar pattern over time and they increase at a decreasing rate and then at an increasing rate. x_{it} is a variable that changes over time and across the observation. There is only one such variable, BIG_RECALL_{it}. Then X_i is the vector of independent variables that do not change over time, which are basically the variables that in the cross-sectional analysis where encompassed by the vectors X_1 and X_2, which include all the language related variables in the letters, as well as the separate discrepancy measure.

4.4. Summary Statistics of the Estimation Sample

Table 4 shows summary statistics for observations included in our econometric models. The total number of observations is 178. The dependent variable is the correction rate. Each recall has 6 correction rates from 6 quarterly reports. The average correction rate for the first quarter is 21.21%, while the average for the last quarter is 59.05%. The NHTSA reports that the overall average correction rate is about 70% in the fourth quarter. In our data set, it is 53.40%. However, our data excludes the recalls with current year-models. Assuming that owners with newer year models are more responsive to recalls, the relatively lower correction rates in our data set should not be too surprising.

The average vehicle age is 2.78 years. The minimum age is 1 year and the oldest vehicles are 14 years old. Note that the latest year-model is used for the variable when there are multiple year models in a recall.

The variables for vehicle types are all dummy variables. In the data set, 12.15% of the recalls involve compact cars, while sedans account for 18.23%. Trucks and motorcycles are 31.5% and 13.81%, respectively. Recalls involving recreational vehicles account for only 5.52%.

Slightly more than 50% of the recalls are issued for foreign vehicles. 58.43% of the recalls are considered as hazardous recalls, and therefore 41.57% of the recalls are non-hazardous recalls. This is the classification from the NHTSA linked to the type of equipment involved in the recall.

About 64% of the recall notification letters contain alerting words, such as "crash", "injury", or "death", but only 10.67% of the letters contain the word, "death."

There are big recalls over the period of study. Over the 4 years (16 quarters), about 56% of the recalls experience big recalls during the quarters when correction rates are reported.[21] About 4% of letters do not reach the owners until the fourth quarter. Manufacturer Dummies are also included to control for manufacturer-specific impacts on the correction rate. We include manufacturers whose recalls consist of more than 3% in the sample.

Figure 2 shows the phrases on risks in the letters. Among the 178 recalls, 63 recalls (about 35%) do not contain any urgent expressions in their notification letters. "Crash without warning" is found in 24 letters. The words, "fire" and "injury", are found in 43 and 26 letters, respectively.[22] The strongest word, "death", is found in 18 recalls. Thus, the variable, *CRASH*, has the value of one in 24 in recalls and zero in 154 recalls. The variable, *CR_IN*, has 90 ones and 88 zeros. The variable, *CR_IN_DE*, has 114 zeros and 64 ones. Finally, the variable, *DEATH*, has 19 ones. Figure 3 shows these results.

Tables 5 presents the breakdown of our dependent variable, the correction rates, by the key variables measuring the information flow between manufacturers and vehicle owners. First, we see the breakdown of the correction rate measured by the constructed hazard recall variable. As could be expected, recalls considered hazardous, given the type of equipment involved, have higher correction rates (measured four quarters after the recall is issued). Notice, however, that the ranges of values of the correction rate is quite high in all cases, but for the more hazardous recalls both the minimum and maximum values are also higher. Then we present the cross-tabulation of the correction rate variables with the four different types of language variables we have constructed from the recall notification letters. We can observe here that the inclusion of the word "crash" does not seem to correlate in a stronger fashion with higher correction rates; in fact, on average, the correction rates are slightly lower than for recalls with letters which do not

[21] Some big recalls are issued at the end of a quarter, such as December. 29. In this case, we consider the fourth quarter does not have big recall, but the first quarter of the next year.

[22] An expression, "Electrical short", is found in one letter, but it often cause fire. Thus these letters are included in "Fire".

include this word. The evidence does point in a much stronger fashion to a positive correlation between the seriousness of the language used and the correction rates once we concentrate on the three variables that reflect stronger wording in the letters. The inclusion of the word "injury" on top of crash is correlated with much higher correction rates, and the same happens with the addition of the word "death." Also, the inclusion of only the word "death," even if not mentioning the other words, is clearly correlated with higher correction rates. All this evidence points in the direction of a correlation between the language used in the notification letters and corrective behavior. However, so far this analysis is unconditional; we proceed to analyze whether this evidence survives in a more careful conditional analysis that accounts for the other variables that could explain corrective behavior by drivers of cars subject to recalls.

The table also shows the tabulation of the correction rate by the variables that try to capture the discrepancies between the language used by manufacturers and the language used by the NHTSA to describe the same recall. The variable *DIFF_MILD* takes the value 1 when we have found sizable language differences between the letter released by the NHTSA about a recall and the language used by the manufacturers in their letter to owners, which indicate milder language in the letter by the manufacturers. We can see in the table that this variable is correlated with considerably lower correction rates. We also show the variable *DIFF_STR* which takes the value 1 when the letter from the manufacturers contains stronger language than the letter from the NHTSA. Interestingly, the latter is also correlated with lower correction rates in this unconditional analysis.

5. Estimation Results

Table 6 presents the first set of estimation results. Two models are presented. MODEL 1-1 does not include manufacturer dummies, while MODEL 1-2 includes the dummies. The estimation results show that the constructed hazard rating, $RISK$, is not associated with the correction rate in the first model for any level of standard statistical significance. When the model includes manufacturer dummies, the rating is estimated to affect the correction rate at the 10% confidence level. If a recall is hazardous, then the correction rate is 4.2% higher than the correction rate of a non-hazardous recall. This result can be compared with the results in Hoffer, Pruitt, and

Reilly (1994), who estimated a similar model using data from 1984 to 1986. They find that the effect of the measure of severity is around 6.8%, considerably higher than our estimate. The result should not be surprising given the fairly long list of omitted variables in their study, which only included five independent variables as opposed to our dozen of variables, not including the manufacturer indicators. We have re-estimated our model trying to mimic Hoffer, Pruitt, and Reilly's specification and found a point estimate of 6%, fairly close, considering the more than two decade difference in the data used, and the difference in the nature of the recalls studied. This goes to show that the point estimate in that study was biased upwards compared with our more detailed specification.

Our findings indicate then that risk levels of defects in part determine owner decisions to correct their defective cars. This means that, up to some level, the current recall system seems to work, given that the riskiness of the defects influences corrective actions. Given the relatively small effect, and its marginal significance, we can suspect that variables that capture the additional details provided by the manufacturers regarding each recall could have an effect. These details are provided in the recall notification letter, and the construction of the variables requires a detailed manual reading of each notification letter, which can be up to 20 pages long. We will analyze the effect of the additional information provided in the letters in the next tables.

If a recall is for a sedan, the correction rate is higher. The correction rate for motorcycle owners is significantly lower and it is statistically significant at the 5% significance level. This may be because there are relatively more unreachable recall letters for motorcycle owners. Our data set shows that the ratio of unreachable letters for motorcycles is much higher than the ratio for other types of vehicles. The ratio for motorcycles is 5.41% on average, while the ratio for non-motorcycles is 3.83%. However, this difference is controlled by the variable $UNREACH$ in our model. Therefore, there must be other reasons why the correction rates are lower for motorcycles. A possible explanation is that the share of expenditure on the motorcycle from the owner's income is smaller than expenditure on other types of vehicles. Another explanation could be that motorcycle owners are relatively risk averse. The same is true for owners of recreational vehicles. The correction rate for recreation vehicles is nearly 25% lower than non-recreational vehicles. The luxury vehicle owners respond to recalls at a higher rate.

The vehicle age is negatively associated with the correction rate and is statistically significant at the 1% level. If a vehicle is one year older, then the correction rate is 10% lower. This has an important implication: Vehicle manufacturers should take recall actions as quickly as possible, once a defect is found. Delaying recall decisions by a year results in a 10% decline in correction rates. Therefore, the effect of recall regulation becomes smaller over time and leads to more car accidents. Furthermore, the relationship is non-linear. Therefore, the older vehicle models the owners have, the lower the correction rate is. However, the correction rate diminishes at a decreasing rate. As we see the estimation results from this and in a later table, the vehicle age effect is consistent over different model specifications.

Both foreign and big recalls do not affect correction rates. When people take corrective actions, big recalls are not a factor they consider.

As expected, the less the letters are able to reach the owners, the lower the correction rates are. It is statistically significant at the 5 to 10% levels. Therefore, in order to increase the overall correction rates, both manufacturers and the NHTSA should try to find ways to minimize the number of unreachable letters. The coefficient of the variable $DURATION$ is statistically significant and has the expected positive sign. Vehicle dummies are included in the estimation but do not appear in the table. The owners of certain manufacturers are more responsive to recalls. We can interpret this as follows: Either some manufacturers manage the recall process fairly well, or vehicle owners of these firms are different from those of other firms in dealing with potential risks.

Notice that the fit of the model is quite good (R^2 around 47% once we introduce manufacturers' dummies) considering that we are estimating a cross-sectional model. The contrast is quite stark compared to Hoffer, Pruitt, and Reilly's (1994) low measure, which was only around 18%. The fit is equally good or better in the rest of the specifications we discuss below.

Table 7 shows the estimation results when we exclude the constructed hazard measure and instead include four different independent variables representing the degree of seriousness of the language in the letter.[23] First, we use the weakest measure, $CRASH$. If the notification letter contains the word, "crash", this does not affect the correction rate in a statistically significant way. Second, we consider recalls that include letters containing either the word "crash" or "injury." The coefficient is still not significant and predicts a very similar effect to the previous

[23] While owners perceive risks differently, since they receive the same recall notification letters, we can estimate the average effect that particular language in the letters has on correction rates.

measure. The third specification adds to the word "death" to *"crash"* or *"injury"*, and it is statistically significant at the 10% level; the result predicts an effect of around 5.3%, considerably higher than the previous cases. Therefore, when the letter includes relatively more alerting expressions, the owner more actively takes corrective actions. Finally, when the letter only includes the word "death," the correction rate of the corresponding recall is 10.9%. This implies that owners take recalls more seriously when the letter explains the defects using stronger words, such as "death." This provides us a policy implication: more detailed description on the risks and all possible consequences from defects help increase the correction rate.

The coefficients of other control variables (in particular those which are statistically significant) are all what we expected and very similar to the previous estimation results, suggesting that the measure we have omitted is not strongly collinear with those we have left in the model. From this analysis, the recall notification letters seem to play an important role in raising the correction rates, and individuals respond more significantly to recalls which can lead to more serious accidents.

Table 7 also includes the variable *DIFF_MILD*, which takes the value 1 for the recalls the letters of notification of which include milder language than the letter from the NHTSA describing the particular recall. The sign of this coefficient is negative, indicating that this discrepancy reduces correction rates, and the size of the coefficient is quite large and statistically significant, varying between 10% and almost 13%, depending on the specification. This effect is quite large, and suggest that these discrepancies are an important issue that opens the discussion of the kind of regulation that should try to prevent these discrepancies. As a sensitivity analysis, we have also included (not shown) in the specifications the variable that measures whether the discrepancies indicate stronger language in the letters from manufacturers than in the description of the NHTSA, but in that case the estimated coefficient is very small, sometimes positive, and not statistically significant. Those results are available from the authors upon request.

Table 8 is similar to Table 7, except that now we also include $RISK$, the constructed measure of how hazardous the recall is based on the type of equipment affected, in the model. Interestingly, once we include this measure, the effect of the language indicators in the letters becomes stronger, especially for the more serious warnings. This means that current recall letters seem to contain additional information from owners' point of view, above and beyond the general importance of the recall, which affect their correction rates. Additionally, notice that the point estimate of the $RISK$ variable is very similar to what we estimated in Model 1-2, and it is very consistent across the different specifications in the table. This suggests that the warnings in the letters about the risks to the owners from a particular recall are capturing an independent source of variation from the baseline effect of the type of equipment. Notice as well that the rest of the coefficients are also quite similar to the previous table, again suggesting that all these measures belong in the specification and are identified in the model. In particular the estimated effect of the variable that captures the worrying discrepancies in the language in the letters, is still statistically significant and the coefficients are basically of the same size.

Table 9 is the estimation results from the (unbalanced) panel data model. The variable, $RISK$, is statistically significant at the 10% level, and we estimate only a slightly smaller effect than in our cross-sectional model, suggesting that the recall specific individual component is well captured by our independent variables. Notice, however, that the effects of the language in the recall letters on the correction rates become somewhat weaker by around 1 percentage point, suggesting a possible recall specific component affecting the particular language of the letters.

The effect of the indicator of discrepancies between the reports of the NHTSA and the language used in the letters are still mostly significant (for the third model in the table the coefficient on the discrepancy is not significant at the 10% level) but the size of the coefficient decreases across the board by around 3 percentage points, but still remains very sizable. We estimate around an 8% decrease in correction rates in the presence of the discrepancies towards milder reports by the manufacturers. If we include in this specification the variable that indicates stronger language by manufacturers (not shown) the estimated coefficient, as in the cross-sectional analysis, is very close to zero, sometimes positive, and not statistically significant. Given that we have data for six quarters, we can estimate whether there is a significant time-trend. We find that the correction rate starts to rise slowly in the first place, and then increases at an increasing rate as the time approaches to the final quarter. All the coefficients that capture time effects are statistically significant at the 1% level. Other independent variables show very similar results to the cross sectional model.

6. Conclusions and Policy Implications

Using data on correction rates for vehicle recalls in the United States from 2007 to 2010, this paper investigates information transmission from manufacturers to owners regarding the defects of recalled vehicles. We find that riskier recalls, measured using a constructed variable that takes into account the equipment involved in the recall, are associated with higher correction rates, and while the effect is statistically significant, the magnitude is not very large; this result is somewhat in line with previous literature using data from the 1980s. We also find that owners of certain vehicle brands and newer year-models respond more actively to vehicle recalls.

Using a careful, manual analysis of NHTSA documentation on each of the recalls we analyze, we are also able to identify the effect of the particular language used in the notification letters on the correction rate. We find that notification letters, through alerting language used to describe the risk of not correcting the defect, play an important role in increasing the correction rates, even after controlling for the constructed measure of hazardous defects. For example, recalls, linked to letters that include the word "*death*" as a possible consequence of the problems in the vehicle, have a correction rate nearly 11% higher than letters that do not include "death". Since the way the recall risk is communicated to owners is currently unregulated and left completely to the manufacturers to decide, our results have important policy implications. In some cases, the letters do not contain enough information on the defects and remedies, even though the defects may cause serious injuries or even death, and in a number of cases there are discrepancies in the language used to describe the consequences of a recall between the NHTSA and the manufacturers.

In our data, we find, for example, that a European manufacturer issued a recall for a given model in 2007 for vehicles with potential problems in the fuel system, so this has to be considered a hazardous recall. Accordingly, the recall notification letter should have indicated the detailed information on the defects and risks. However, the letter does not include any possible consequences of the problem at hand. The document submitted and used by the NHTSA mentions the defect's consequences using the phrase, "fuel leakage in the presence of an ignition source could result in a fire." However, the recall notification letter sent out to owners explains the consequences using weaker language: "The fuel pump may become faulty, resulting in a strong fuel smell." Thus, unless owners of these vehicles visit the NHTSA website and actively seek possible consequences of the problem the manufacturer describes, owners may think that the defect is minor, and the correction rate could be lower than expected. Therefore, unless there is a consistent way to convey risks to owners of recalled vehicles, there could be discrepancies between actual and perceived risks. In another case, also with a European manufacturer, the NHTSA alerts that a particular equipment malfunction can lead to problems in the fuel pump that could create the "...potential for a crash resulting in injury or death." instead of using this language, the manufacturer chooses to include the following in the letter: "Depending on traffic and road conditions, and the driver's reactions, this could increase the risk of a crash." Clearly, the manufacturer includes milder language, and the absence of the NHTSA's keywords is predicted to decrease correction rates significantly. In fact, we find that recalls that exhibit a discrepancy that indicates milder language used in the notification letters, are estimated to lead to significantly lower correction rates of between 8% and 13%, depending on the specification.

Our results can be of potential relevance to other fields, since the use of notification letters is also commonplace in other industries, like the medical devices industry regulated by the FDA. In that setting the lack of regulation of these letters has also opened a discussion among experts about how to better transmit information to owners of products subject to recalls.

Short of perfectly controlling the full content of letters, the NHTSA can return to its pre-2001 policy of rating the recalls itself, and the agency could require that the manufacturers include this rating in the letters to owners, in addition to the explanations the manufacturers already include. Additionally, the NHTSA could mandate that manufacturers also include information about the particular recall, like the number of accidents, complaints, people injured, and people who have died in connection with the recalled defect. This additional information would help owners accurately evaluate the potential danger of their vehicles. Notice that the cost of adding this new information would not be substantial because both manufacturers and the NHTSA have issued recalls based on this information. The information is already posted on the NHTSA web site, but it would be more effective if this information appeared in the letters.

Table 1. Recalls between 2007 and 2010

Variable	Category	Frequency	Percent	Variable	Category	Frequency	Percent
Types of Recall	Components	33	1.19	**Vehicle Recalls by Year**	2007	586	24.34
	Equipments	293	10.52		2008	682	28.32
	Tires	50	1.80		2009	492	20.43
	Vehicles	2,408	86.49		2010	648	26.91
	Total	2,784	100.00		Total	2,408	100.00
Initiation	Manufacturer	1,763	73.21	**Total† Vehicles Included**	2007	14.82	24.07
	ODI	604	25.08		2008	10.10	16.41
	OVSC	41	1.70		2009	16.57	26.92
					2010	20.07	32.60
	Total	2,408	100.00	Total		61.55 ‡	100.00

† Only vehicle recalls are included.
‡ Units used: one million vehicles.

Table 2 Types of Defects

Types of Defects	Frequency	Percent	Frequency	Percent
Air Bags	55	1.98	53	2.20
Child Seat	34	1.22	2	.08
Electrical System	151	5.42	144	5.98
Engine and Engine Cooling	214	7.69	198	8.22
Equipment	920	33.05	801	33.26
Exterior (Interior) Lightening	132	4.74	91	3.78
Fuel System	142	5.10	130	5.40
Power Train	119	4.27	108	4.49
Seat Belts	103	3.70	92	3.82
Service Breaks	215	7.72	201	8.35
Steering	170	6.11	156	6.48
Structure	110	3.95	108	4.49
Suspension	114	4.09	96	3.99
Tires	62	2.23	12	.50
Vehicle Speed Control	30	1.08	29	1.20
Visibility, Windshields	66	2.37	60	2.49
Wheels	39	1.40	32	1.33
Other	110	3.95	95	3.95
Total	2,784	100.00	2,408	100.00

Figure 1 Types of Defects

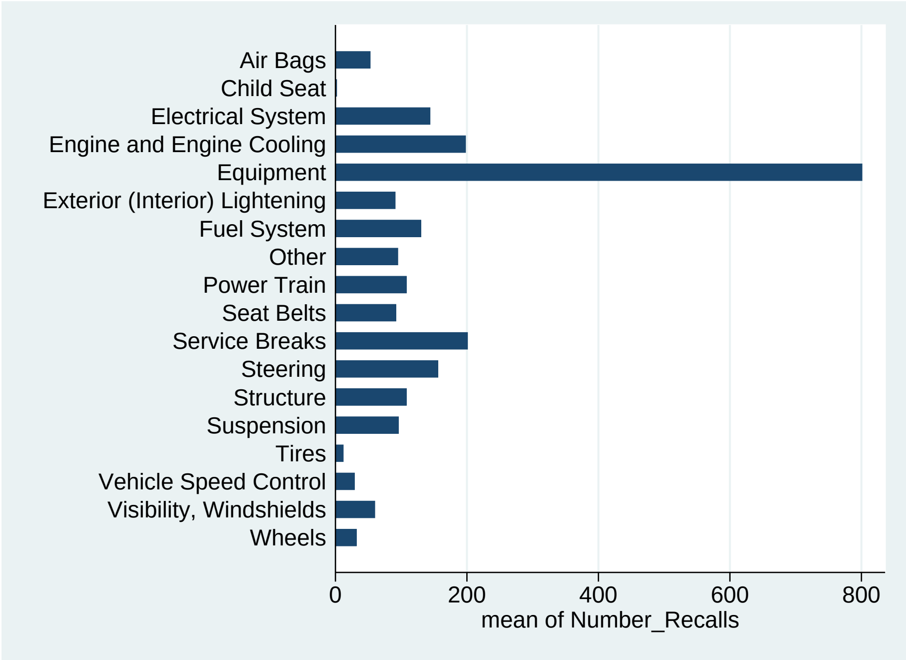


Table 3. Potential Number of Units Affected

Numbers of Vehicles	Recalls	Average Units	Total Units	Percent	Cum. Percent
1 - 1,000	1,523	202.31	308,116	.50	.50
1,001 - 10,000	505	3,449.16	1,741,826	2.83	3.33
10,001 - 100,000	257	34,992.05	8,992,956	14.61	17.94
100,001 - 1,000,000	103	265,913.10	27,389,045	44.50	62.44
More than 1,000,000	11	2,102,070.00	23,122,766	37.56	100.00
	2,399		61,554,709	100.00	100.00

† There is no data on the units for 9 recalls.

Table 4. Summary Statistics

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variable:						
Correction Rate 1	175	.2121	.1797	0	.7636	RATE_1
Correction Rate 2	173	.3866	.1975	.0058	.9558	RATE_2
Correction Rate 3	178	.4763	.2069	.0177	.9762	RATE_3
Correction Rate 4	178	.5340	.2128	.0179	.9762	RATE_4
Correction Rate 5	178	.5658	.2121	.0181	.9895	RATE_5
Correction Rate 6	175	.5905	.2134	.0190	.9948	RATE_6
Independent Variables						
Model Year	181	2005.66	2.3123	1993	2009	MODEL_YEAR
Units Affected	181	73440.06	146786.8	1008	1128659	UNITS
Manufacturer Initiation	181	.6243	.4856	0	1	INITIATE
Vehicle Age	181	2.7790	1.9877	1	14	VEH_AGE
Vehicle Age Squared	181	11.6519	19.1832	1	196	VEH_AGE_SQ
Compact	181	.1215	.3277	0	1	COMPACT
Sedan	181	.1823	.3872	0	1	SEDAN
SUV	181	.2431	.4301	0	1	SUV
Truck	181	.3149	.4658	0	1	TRUCK
Motor Cycle	181	.1381	.3460	0	1	MOTOR
Luxury Vehicle	181	.1381	.3460	0	1	LUXURY
Recreational Vehicle	181	.0552	.2291	0	1	RV
Foreign Vehicle	181	.5304	.5005	0	1	FOREIGN
Hazard Rating	178	.5843	.4942	0	1	RISK
Letter Crash Only	178	.1348	.3425	0	1	CRASH
Letter Crash or Injury	178	.5056	.5014	0	1	CR_IN
Letter Crash, Injury, or Death	178	.6404	.4812	0	1	CR_IN_DE
Letter Death Only	178	.1067	.3097	0	1	DEATH
Letter with Milder Phrases	178	.0787	.2700	0	1	DIFF_MILD
Letter with Stronger Phrases	178	.1236	.3300	0	1	DIFF_STR
Letter with Phrase Changes	178	.2022	.4028	0	1	DIFF
Big Recalls	181	.5635	.4973	0	1	BIG_RECALL
Duration	181	39.5083	40.9259	0	290	DURATION
Unreachable Letter	181	.0398	.0661	0	.5870	UNREACH
Manufacturer Dummy (Honda)	181	.0497	.2180	0	1	HONDA
Manufacturer Dummy (BMW)	181	.0387	.1934	0	1	BMW
Manufacturer Dummy (Volvo)	181	.0387	.1934	0	1	VOLVO
Manufacturer Dummy (Volkswagen)	181	.0277	.1643	0	1	VOLKSWAGEN
Manufacturer Dummy (Dodge)	181	.0442	.2061	0	1	DODGE
Manufacturer Dummy (Ford)	181	.0276	.1643	0	1	FORD
Manufacturer Dummy (Toyota)	181	.0442	.2061	0	1	TOYOTA
Manufacturer Dummy (Chevrolet)	181	.0387	.1934	0	1	CHEVROLET
Manufacturer Dummy (Nissan)	181	.0331	.1795	0	1	NISSAN
Manufacturer Dummy (Mitsubishi)	181	.0276	.1643	0	1	MITSUBISHI

Figure 2. Description of Risk in the Letters: Estimation Sample

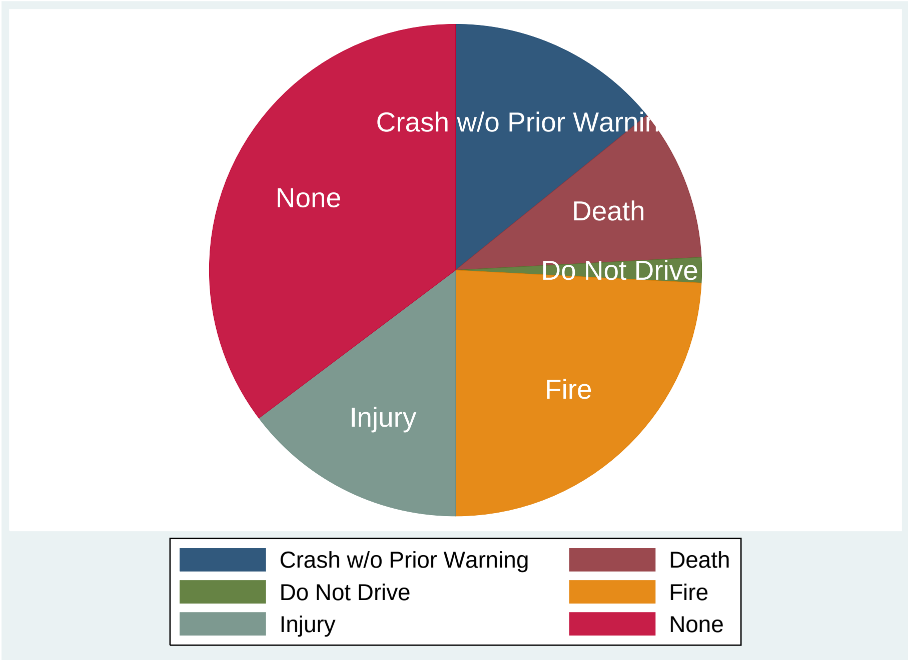
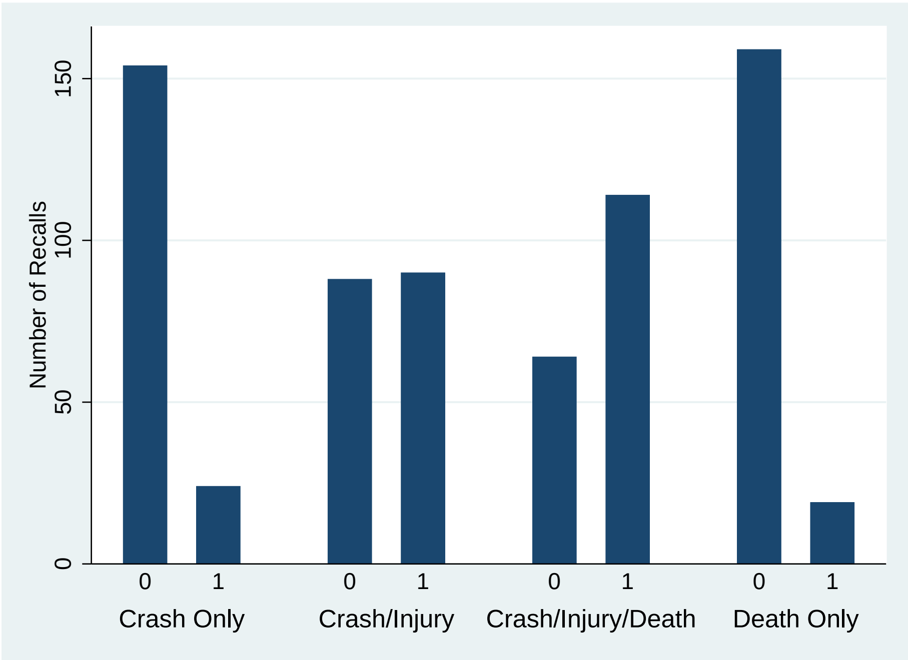


Figure 3. Description of Risk in the Letters: Frequency Graph



† Some letters include multiple expressions.

Table 5. Correction Rates by Hazard Levels and Variables in the Letters

Variable	Obs	Mean	SD	Min	Max
$RISK = 1$	104	.5624	.2131	.0257	.9762
$RISK = 0$	74	.4941	.2072	.0179	.9456
$CRASH = 1$	24	.5321	.2033	.1589	.7807
$CRASH = 0$	154	.5343	.2148	.0179	.9762
$CR\_IN = 1$	90	.5543	.2043	.0280	.9762
$CR\_IN = 0$	88	.5132	.2203	.0179	.8547
$CR\_IN\_DE = 1$	114	.5497	.2034	.0280	.9762
$CR\_IN\_DE = 0$	64	.5061	.2274	.0179	.8547
$DEATH = 1$	19	.5905	.1841	.2636	.9575
$DEATH = 0$	159	.5272	.2155	.0179	.9762
$DIFF\_MILD = 1$	14	.4555	.2882	.0256	.8547
$DIFF\_MILD = 0$	164	.5407	.2048	.0179	.9762
$DIFF\_STR = 1$	22	.4857	.1696	.2222	.8093
$DIFF\_STR = 0$	156	.5408	.2177	.0179	.9762

Table 6. Determinants of Correction Rates without Letter Variables

	MODEL 1-1	**MODEL 1-2**
Manufacturer Dummies	No	Yes
Constant	.6979 (.0467)***	.6961 (.0517)***
RISK	.0383 (.0249)	.0424 (.0257)*
COMPACT	.0217 (.0419)	.0131 (.0439)
SEDAN	.0831 (.0446)*	.0868 (.0447)*
SUV	.0529 (.0398)	.0507 (.0409)
MOTORCYCLE	-.1063 (.0479)**	-.1375 (.0493)***
LUXURY	.0753 (.0356)**	.0629 (.0380)*
RV	-.2490 (.0742)***	-.2429 (.0781)***
FOREIGN	-.0269 (.0282)	-.0437 (.0384)
VEH_AGE	-.1029 (.0145)***	-.0961 (.0158)***
VEH_AGE_SQ	.0059 (.0012)***	.0055 (.0013)***
UNREACH	-.3857 (.1817)**	-.3399 (.1782)*
BIG_RECALL	.0180 (.0245)	.0125 (.0253)
DURATION	.0009 (.0003)***	.0006 (.0003)**
NUM of OBS	178	178
R^2	.4355	.4719

Note : Standard errors are in parentheses.

The Huber/White/sandwich estimator of variance is used.

*, **, *** : Significant at the 10-, 5-percent level, and 1-percent level respectively.

Both *BMW* and *Volkswagen* are statistically significant. These dummies are positively associated with the correction rate.

Table 7. Determinants of Correction Rates with Letter Variables

	MODEL 2-1	**MODEL 2-2**	**MODEL 2-3**	**MODEL 2-4**
Expression In the Letter	CRASH Only	CRASH or INJURY	CRASH, INJURY or DEATH	DEATH Only
Constant	.7340 (.0516)***	.7119 (.0537)***	.6952 (.0521)***	.7022 (0.0514)***
RISK	-	-	-	-
CRASH	.0287 (.0410)	-	-	-
CR_IN	-	.0295 (.0273)	-	-
CR_IN_DE	-	-	.0530 (.0281)*	-
DEATH	-	-	-	.1091 (.0572)*
DIFF_MILD	-.1289 (.0483)***	-.1152 (.0496)**	-.1017 (.0486)**	-.1177 (.0478)**
COMPACT	-.0086 (.0421)	-.0025 (.0417)	-.0045 (.0433)	.0092 (.0417)
SEDAN	.0821 (.0438)*	.0895 (.0423)**	.0968 (.0433)**	.0955 (.0427)**
SUV	.0456 (.0394)	.0475 (.0398)	.0489 (.0390)	.0556 (.0404)
MOTORCYCLE	-.1377 (.0465)***	-.1333 (.0450)***	-.1338 (.0456)***	-.1561 (.0461)***
LUXURY	.0725 (.0410)*	.0753 (.0393)*	.0691 (.0404)*	.0747 (.0393)*
RV	-.2495 (.0776)***	-.2472 (.0757)***	-.2305 (.0766)***	-.2324 (.0756)***
FOREIGN	-.0361 (.0372)	-.0433 (.0353)	-.0405 (.0356)	-.0387 (.0345)
VEH_AGE	-.1007 (.0165)***	-.0962 (.0156)***	-.0996 (.0156)***	-.0951 (.0153)***
VEH_AGE_SQ	.0060 (.0013)***	.0056 (.0012)***	.0059 (.0012)***	.0057 (.0012)***
UNREACH	-.4108 (.1780)**	-.4157 (.1744)**	-.4385 (.1729)**	-.4100 (.1920)**
BIG_RECALL	.0122 (.0261)	.0124 (.0263)	.0127 (.0262)	.0127 (.0256)
DURATION	.0006 (.0003)**	.0007 (.0003)**	.0006 (.0003)**	.0007 (.0003)**
NUM of OBS	178	178	178	178
R^2	.4906	.4926	.4989	.5088

Note : Standard errors are in parentheses.The Huber/White/sandwich estimator of variance is used.

*, **, *** : Significant at the 10-, 5-percent level, and 1-percent level respectively. Manufacturer dummies are included in the estimation, but not reported in the table.

Table 8. Determinants of Correction Rates: Full Model

	MODEL 3-1	MODEL 3-2	MODEL 3-3	MODEL 3-4
Expression In the Letter	CRASH Only	CRASH or INJURY	CRASH, INJURY or DEATH	DEATH Only
Constant	.7188 (.0521)***	.6979 (.0550)***	.6757 (.0547)***	.6853 (.0518)***
RISK	.0465 (.0246)*	.0431 (.0248)*	.0480 (.0251)*	.0473 (.0248)*
CRASH	.0371 (.0397)	-	-	-
CR_IN	-	.0293 (.0271)	-	-
CR_IN_DE	-	-	.0580 (.0290)**	-
DEATH	-	-	-	.1136 (.0563)**
DIFF_MILD	-.1295 (.0486)***	-.1161 (.0502)**	-.1000 (.0495)**	-.1181 (.0484)**
COMPACT	-.0064 (.0425)	.0002 (.0420)	-.0013 (.0437)	.0128 (.0422)
SEDAN	.0813 (.0438)*	.0886 (.0427)**	.0973 (.0435)**	.0952 (.0431)**
SUV	.0472 (.0401)	.0489 (.0406)	.0507 (.0397)	.0576 (.0417)
MOTORCYCLE	-.1481 (.0471)***	-.1426 (.0453)***	-.1439 (.0459)***	-.1671 (.0461)***
LUXURY	.0655 (.0404)	.0697 (.0386)*	.0623 (.0398)	.0685 (.0388)*
RV	-.2352 (.0757)***	-.2355 (.0744)***	-.2152 (.0752)***	-.2186 (.0743)***
FOREIGN	-.0448 (.0379)	-.0521 (.0361)	-.0505 (.0361)	-.0484 (.0352)
VEH_AGE	-.1020 (.0163)***	-.0967 (.0154)***	-.1002 (.0155)***	-.0954 (.0151)***
VEH_AGE_SQ	.0060 (.0012)***	.0056 (.0012)***	.0058 (.0012)***	.0056 (.0011)***
UNREACH	-.3695 (.1783)**	-.3755 (.1748)**	-.3970 (.1722)**	-.3661 (.1959)*
BIG_RECALL	.0065 (.0253)	.0071 (.0254)	.0068 (.0253)	.0069 (.0246)
DURATION	.0006 (.0003)*	.0006 (.0003)**	.0006 (.0003)*	.0006 (.0003)**
NUM of OBS	178	178	178	178
R^2	.5001	.5009	.5092	.5188

Note : Standard errors are in parentheses. The Huber/White/sandwich estimator of variance is used.

*, **, *** : Significant at the 10-, 5-percent level, and 1-percent level respectively. Manufacturer dummies are included in the estimation, but not reported in the table.

Table 9. Random Trend Panel Data Model

	MODEL 4-1	**MODEL 4-2**	**MODEL 4-3**	**MODEL 4-4**
Expression In the Letter	CRASH Only	CRASH or INJURY	CRASH, INJURY or DEATH	DEATH Only
RISK	.0411 (.0232)*	.0390 (.0231)*	.0418 (.0230)*	.0420 (.0227)*
CRASH	.0244 (.0341)	-	-	-
CR_IN	-	.0253 (.0238)	-	-
CR_IN_DE	-	-	.0442 (.0258)*	-
DEATH	-	-	-	.1054 (.0379)***
DIFF_MILD	-.0889 (.0413)**	-.0773 (.0428)*	-.0666 (.0432)	-.0781 (.0406)*
COMPACT	.0182 (.0434)	.0222 (.0433)	.0206 (.0431)	.0349 (.0428)
SEDAN	.0770 (.0419)*	.0834 (.0422)**	.0882 (.0421)**	.0894 (.0412)**
SUV	.0472 (.0333)	.0486 (.0333)	.0491 (.0332)	.0565 (.0328)*
MOTORCYCLE	-.1186 (.0431)***	-.1141 (.0430)***	-.1145 (.0428)***	-.1352 (.0426)***
LUXURY	.0456 (.0439)	.0486 (.0436)	.0430 (.0435)	.0473 (.0428)
RV	-.2036 (.0519)***	-.2021 (.0518)***	-.1884 (.0525)***	-.1863 (.0510)***
FOREIGN	-.0244 (.0348)	-.0303 (.0347)	-.0281 (.0344)	-.0262 (.0339)
VEH_AGE	-.0812 (.0142)***	-.0773 (.0139)***	-.0798 (.0138)***	-.0757 (.0136)***
VEH_AGE_SQ	.0044 (.0014)***	.0041 (.0014)***	.0043 (.0014)***	.0041 (.0013)***
UNREACH	-.3735 (.1662)**	-.3797 (.1661)**	-.3993 (.1661)**	-.3756 (.1625)**
BIG_RECALL	-.0015 (.0053)	-.0015 (.0053)	-.0014 (.0053)	-.0015 (.0053)
DURATION	.0010 (.0003)***	.0011 (.0003)***	.0010 (.0003)***	.0011 (.0003)***
TIME	.3356 (.0240)***	.3356 (.0240)***	.3356 (.0240)***	.3355 (.0240)***
TIME_SQ	-.0640 (.0077)***	-.0640 (.0077)***	-.0640 (.0077)***	-.0640 (.0077)***
TIME_3	.0044 (.0007)***	.0044 (.0007)***	.0044 (.0007)***	.0044 (.0007)***
Num of Obs	1,057	1,057	1,057	1,057
Num of Group	181	181	181	181
R^2: Within	.7817	.7817	.7817	.7817
R^2: Between	.4861	.4880	.4935	.5075
R^2: Overall	.6004	.6017	.6051	.6132

Note : Standard errors are in parentheses.

*, **, *** : Significant at the 10-, 5-percent level, and 1-percent level respectively.

Manufacturer dummies and a constant are included in the estimation, but not reported in the table.

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