Report to Congress:

“Vehicle Safety Recall Completion Rates Report”

Prepared by the

U.S. Department of Transportation

National Highway Traffic Safety Administration

December 2018 Biennial Report (#2 of 3)

This report is submitted in response to the request by Congress under the new transportation reauthorization bill, the Fixing America’s Surface Transportation Act (FAST Act). The FAST Act authorizes funds for Federal-aid highways, highway-safety programs, transit programs, and other purposes.

CONTENTS

I. INTRODUCTION

On December 4, 2015, President Obama signed into law the Fixing America's Surface Transportation Act (FAST Act). This bill provides long-term funding for Federal-aid highways, highway-safety programs, transit programs, and other purposes.

Section 24104 of the FAST Act, "Recall Process" states that:

(c) RECALL COMPLETION RATES REPORT.— (1) IN GENERAL.—Not later than 1 year after the date of enactment of this Act, and biennially thereafter for 4 years, the Secretary shall—

> (A) conduct an analysis of vehicle safety recall completion rates to assess potential actions by the National Highway Traffic Safety Administration to improve vehicle safety recall completion rates; and
>
> (B) submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Energy and Commerce of the House of Representatives a report on the results of the analysis.

(2) CONTENTS.—Each report shall include—

> (A) the annual recall completion rate by manufacturer, model year, component (such as brakes, fuel systems, and air bags), and vehicle type (passenger car, sport utility vehicle, passenger van, and pick-up truck) for each of the 5 years before the year the report is submitted;
>
> (B) the methods by which the Secretary has conducted analyses of these recall completion rates to determine trends and identify risk factors associated with lower recall rates; and

(C) the actions the Secretary has planned to improve recall completion rates based on the results of this data analysis.

This report, the second of three required reports, responds to the FAST Act requirement that the Secretary of Transportation conduct an analysis of vehicle safety recall completion rates and submit the findings of that report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee of Energy and Commerce of the House of Representatives.

II. BACKGROUND

The National Highway Traffic Safety Administration ("NHTSA" or "the Agency") works each day to administer safety recalls in accordance with the National Traffic and Motor Vehicle Safety Act ("the Safety Act"). *See* 49 U.S.C. § 301 *et seq*. Safety recalls are conducted when manufacturers of motor vehicles or motor vehicle equipment determine that a safety defect is present in the manufacturer's product or that the product does not conform to an applicable federal motor vehicle safety standard.[1] When a manufacturer issues a safety recall, 49 CFR Parts 573 and 577 require, among other things, the manufacturer to complete the following:

i. Notify the Agency with a Part 573 Recall Report which identifies the recalled product, summarizes the safety problem, and details the manufacturer's plans to offer a free remedy.

ii. Notify owners and purchasers, by First Class mail, of the recall and the available free remedy to address the safety risk.

iii. Report to the Agency for six quarters the number of recalled products that have been remedied by the manufacturer.

[1] 49 U.S.C. § 30118 also authorizes the Secretary of Transportation to decide when a motor vehicle or motor vehicle equipment contains a safety defect or a noncompliance with a federal motor vehicle safety standard.

The quarterly reports include counts for how many vehicles were remedied; how many were inspected but no remedy was required; and how many were exported, stolen, scrapped, or the owner could not be reached (e.g., undeliverable mail).

III. METHODOLOGY, DATA CONSTRAINTS, AND OTHER CONSIDERATIONS

NHTSA's methodology for examining recall quarterly reports is as follows:

a. Scope of this Report

The FAST Act specifies light vehicle applications to be studied. NHTSA categorizes light vehicles into three major categories: Light Trucks, Multipurpose Passenger Vehicles ("MPV") such as sport utility vehicles ("SUV") and minivans, and Passenger Cars. For each category, the Agency examined the number of vehicles that were reported as being remedied. Excluded from this report are recalls which include a combination of both light and heavy-duty vehicles, as it is not possible to separate the light vehicle remedy rates from the heavy-duty remedy rates.[2]

Many safety recalls involve more than one type of light vehicle. For example, Toyota recall 12V-491 (Subject: Power Window Master Switch May Melt) includes the Toyota Camry (passenger car), Toyota RAV4 (MPV), and Toyota Tundra (light truck), among other models. Of the 1,097 recalls analyzed in this report received between 2012 and 2016, 200 recalls (18%) involved a combination of passenger cars, MPVs, and light trucks. As such, the Agency created

[2] Sections III.c.4-5 provide additional details about this data limitation.

an additional category labeled "Mix" for this report to indicate recalls that include a combination of vehicle types.

For this report, the Agency examined recalls issued between 2012 and 2016 in which the manufacturer reported the recall's completion status for at least five quarters after the remedy program became available (as of January 1, 2018). Only the fifth-quarter rate was analyzed even if more recent quarterly reports were available. This refinement over the previous analysis serves to control for variability in the length of reporting periods among manufacturers, as some companies continue to submit well after the minimum statutory requirement. Recalls that had not reached this fifth-quarter maturation point—including recalls filed in calendar year (CY) 2017—were not included because these recalls would similarly distort the completion picture.

b. Calculating Recall Completion Rates

The Agency uses a standard formula for measuring recall completion. This formula is the number of vehicles reported as remedied (including vehicles reported as inspected but not requiring remedy and vehicles returned to inventory) divided by the total number of vehicles involved in the recall (less any vehicles reported as being exported, stolen, scrapped, or unavailable for other legitimate reasons). NHTSA's completion rate formula is:

Recall Completion Rate =

$$\left(\frac{\text{Count of Vehicles Remedied}}{\text{Count of Vehicles in Recall} - \text{Vehicles Exported, Stolen, Scrapped, Other}} \right) * 100$$

This report will reference the annual completion rate. This rate is a volume-based, weighted metric, such that the more vehicles affected by the recall, the more weight or influence it has on the computed rate. For example, General Motors' (GM) annual completion rate in 2014 was 56% because GM remedied 56% of the vehicles it recalled that year. An alternative metric is the average completion rate, in which each of a manufacturer's recalls carry the same influence or weight relative to other recalls. Using the same example as above, the average (unweighted) completion rate was 78% for GM recalls in 2014. This significant difference is due to the high completion rates of some smaller GM recalls that year and a few larger recalls with relatively low completion rates. All unweighted averages referenced in this report will be specifically designated as "unweighted."

c. Limitations of the Data

This report compares recall completion rates among multiple variables, including the manufacturers and vehicle components involved. However, the Agency notes that the findings provide only a partial picture. The Agency understands myriad factors affect recall completion rates and many of these factors are intangible, difficult (if not impossible) to measure quantitatively, and/or not available to NHTSA. Accordingly, this report will provide metrics and analysis based on data that NHTSA receives and maintains, but the following caveats should be noted:

1. No demographic information: Owner demographics, including socioeconomic factors and location of residence, as well as each owner's subjective assessment of risk, are believed to play a significant role in recall completion. However, this data is not available to the Agency.

2. *Limited verification of manufacturer-supplied figures:* The Agency is unable to verify the numbers of remedied vehicles reported by manufacturers with the limited data available to it. Likewise, the Agency cannot independently verify the numbers of vehicles reported by manufacturers as exported, stolen, scrapped, or otherwise legitimately deducted from the number of vehicles recalled.

3. *Initial parts shortages and restrictions:* Parts delays and shortages can affect the availability of a recall remedy, particularly when a manufacturer first launches a remedy program. Such delays and parts shortages could thus be a factor in recall completion, especially if vehicle owners become frustrated or apathetic after attempting to obtain a remedy that is not yet available. When the Takata air bag recalls began, for example, several recalls were delayed or forced to use a phased launch due to a lack of available parts. However, given the limited data available, the Agency is unable to reliably measure the connection or the magnitude of any impact such a delay may have on recall completion rates.

4. *No detailed model year breakdown:* As discussed later in this report (see Section IV.b), recall completion rates appear to be significantly impacted by the age of the vehicles involved. However, NHTSA only receives data for the total number of vehicles affected and repaired for a given recall without any breakdown for vehicle age. A recall impacting 100,000 model years 2014 and 2015 Honda Civics might include 99,000 model year 2014 vehicles and 1,000 model year 2015 vehicles, or vice versa. Without that breakdown, NHTSA is unable to determine how many vehicles of each model year had been remedied, and thus is limited in its ability to measure the precise effect that vehicle age has on recall completion rates.

5. No detailed model breakdown: A safety recall can include a variety of models. However, as with model years, manufacturers are not required to report their recall populations providing this level of granularity. For example, a Ford recall for 1 million vehicles might include the Ford Explorer and the Ford Mustang. However, the specific number of affected Explorers versus Mustangs would not be provided to NHTSA. Similarly, when the manufacturer submits its quarterly completion reports, it would not be clear how many Explorers were remedied versus the number of Mustangs remedied.

6. No measure of severity: NHTSA does not categorize recalls according to the degree of risk they pose. Although all recalls address safety risks, vehicle owners might be less motivated to seek a remedy for a matter they perceive to be "low-risk." In this analysis, NHTSA attempts to control for severity by examining recalls with descriptions which mention a vehicle crash or fire. But this control is imperfect. These terms may not necessarily be used in only the most high-risk recalls, or they may be used when describing recalls that are not perceived to be particularly high-risk. For example, the word "crash" might be included in the recall description for an incorrect tire pressure label because overinflated tires could explode and cause a crash. Nonetheless, some owners might not perceive the risk of an incorrect label as severe enough to warrant obtaining the remedy.

7. No measure of cost: A vehicle owner may be more likely to take advantage of a free repair for an issue he or she perceives would be costly under normal repair circumstances. However, the Agency does not have data indicating how much each recall remedy costs (or is perceived by owners to cost).

8. *Inconsistent component classification:* This analysis uses a component classification that is determined by NHTSA's analysis of the Part 573 Recall Reports it receives. While NHTSA strives to be consistent in its classification choices, a degree of subjectivity is required when aligning manufacturers' coding with the Agency's classification scheme, given the variety of components that can necessitate a recall. Also, inconsistencies across manufacturers can present challenges to utilizing a uniform taxonomy for vehicle components.

9. *Limited time period:* The analysis in this report is based on recalls that were issued between 2012 and 2016. To the extent that the recalls undertaken during this time period were not representative or materially different in other time periods, the results of this analysis might not be applicable.

d. What Can and Cannot be Concluded from this Analysis

The analysis found in this report is presented in two parts. Sections IV and V.b present "raw data" on which no statistical modeling has been performed. Sections V.c through V.e present results from a statistical model.

Using the raw data, the Agency can draw some tentative conclusions, but these should be viewed cautiously. For example, Figure 1 (see Section IV.a) indicates that some manufacturers tend to have higher recall completion rates. However, this may be misleading because manufacturers issued different types of recalls between 2012 and 2016. Some manufacturers had more air bag recalls, while some had more seat belt recalls. Some manufacturers had multiple recalls involving older vehicles, while some manufacturers had recalls for newer vehicles.

NHTSA attempted to draw stronger conclusions by developing a statistical model but those results remain constrained by the information available to it. As noted above (see Section III.c), the Agency lacks data on many factors that may affect recall completion rates to varying degrees. For example, Toyota might have a higher recall completion rate than a smaller manufacturer for a given recall. While true, the difference might be explained by information not available to NHTSA, such as the demographics of Toyota owners, the perceived risk of the defects, or the perceived costs of the remedies. The performance differential could also be impacted by the particular recalls issued between 2012 and 2016. If the Agency fit the same model to an earlier or later period of light vehicle recalls, the difference in recall completion rates between Toyota and a smaller manufacturer could potentially increase or decrease—or disappear entirely.

Moreover, it is difficult for NHTSA to conclude that any manufacturer truly performed "better" than any other manufacturer, or that recalls for any particular component are truly problematic when considering lower than average completion rates. The figures that appear to support any such conclusion could, in theory, be explained by data not available in this analysis.

IV. ANNUAL RECALL COMPLETION RATES

a. Annual Rates by Manufacturer

Appendix A details the annual recall completion rates, by manufacturer, for light vehicle recalls issued between years 2012 and 2016. Forty-four manufacturers are detailed in the table located in Appendix A. However, the vast majority of light vehicles recalled between 2012 and 2016 (over 98%) were recalled by the major vehicle manufacturers which support NHTSA's VIN Look-up Tool found on www.safercar.gov.[3] Annual recall completion rates for these manufacturers are provided in the following figures.

[3] Manufacturers which support the Agency's VIN Look-up Tool are listed here: https://vinrcl.safercar.gov/vin/.

Figure 1
Completion Rates by Major Manufacturers, 2012-2016 (5Q recalls)

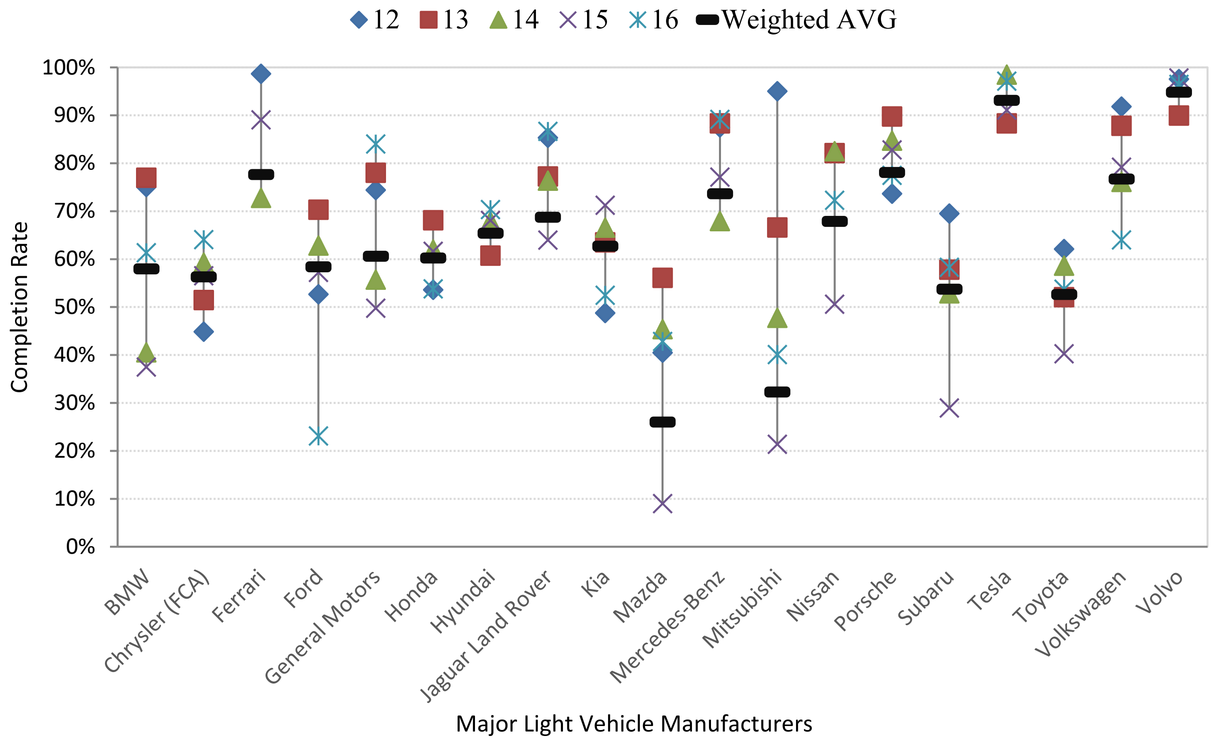


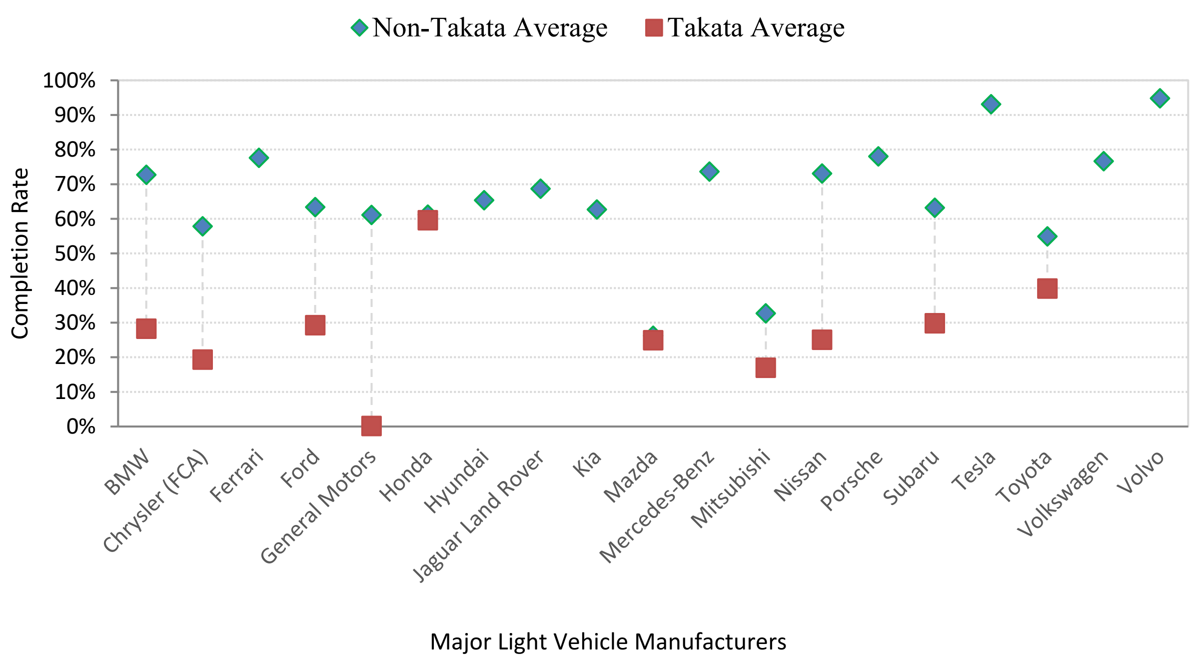
Figure 1 displays the major manufacturers of light vehicles and the ranges of their annual completion rates.[4] For these manufacturers, the combined annual completion rate is 58.4%, meaning more than 58% of all vehicles recalled were remedied.[5] Ferrari and Tesla reached the highest annual completion rates with 99% and 98%, respectively, of their vehicles remedied in a

[4] Figure 1 does not imply any relationship between years.

[5] By contrast, NHTSA's first completion rate report, submitted to Congress in May 2017, reported an overall completion rate of 67%. The nine-percentage-point difference is in large measure due to the Agency's decision to change when in the life cycle it measured recall completion. In the last completion rate report, the Agency's analysis considered the most recently filed quarterly report, which could be the sixth report, or a later report if the manufacturer submitted additional reports beyond the six required reports. For this report, the Agency decided to consider the fifth quarterly report across all recalls in its analysis in order to support a more consistent approach. The Agency performed a retroactive analysis of the data set from its first report and found that the overall completion rate for that data set of recalls would have been 60% -- a two-percentage-point difference.

given year. Volvo achieved a 90% or greater completion rate in each of the four years in which it had a recall. The lowest annual completion rate was Mazda with 9% of its vehicles being remedied for recalls issued in 2015. Note that this year was an outlier for Mazda, as the 2015 rate was pulled downward by a large recall of very old vehicles affected by a potentially overheating ignition switch. In certain years, Ford, Mitsubishi, and Subaru also experienced relatively low completion rates in the 20 to 30% range. The weighted average for each manufacturer is included in Figure 1 to provide a more balanced indicator of performance over the five-year period.

Figure 1b
Non-Takata vs Takata-Only Average Completion Rates for 2012-2016
(5Q recalls)



As shown in Figure 1b, the massive Takata air bag recall has had an adverse impact on the completion averages for many of the major manufacturers' recall rates. Due to the size of the collective manufacturers' recall programs, replacement parts supply was a significant problem.

NHTSA, therefore, created a first of its kind Coordinated Remedy Program to prioritize the restricted parts supply to the highest-risk vehicles and organized a recall schedule to ensure an objective, risk-based approach across manufacturer brands. The highest-risk vehicles, as a general matter, are comprised of the oldest vehicles that reside year-round in geographic areas with sustained hot and humid conditions.

As discussed in the first report to Congress issued in May 2017, and in this report, the age of a vehicle at time of recall is a statistically significant and well-known predictor of whether a recalled vehicle is remedied. It is not surprising, therefore, that the high-volume Takata recalls launched during this period have had a demonstrable effect on lowering the average recall completion rates.[6] This adverse impact is observed whether viewed using a weighted or an unweighted calculus.

Figure 1b shows the weighted average across the five-year span, for non-Takata campaigns and for Takata-only campaigns.[7] The adverse impact can be seen more readily when analyzing the rates by year and manufacturer. When considering all Nissan recall campaigns issued in 2015, for example, their completion rate is 50.6%. However, the percentage increases to 65% when considering only non-Takata campaigns for that same year. A similar, but more pronounced effect occurs with Subaru in 2015. All Subaru campaigns collectively achieved a relatively low rate of 29.0% in 2015, but without Takata campaigns included in that figure, the completion percentage is a high 85%.

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[6] This impact was not observed in the Agency's prior report because the set of recalls causing this impact had either not launched their remedy programs or had not reached an acceptable maturation threshold during the time frame considered in the last report to Congress.

[7] Some manufacturers did not have any mature Takata recalls, either because their recalls had not yet reached the fifth quarter of reporting or because the manufacturers were not part of the Takata recall.

b. Annual Rates by Model Year

Figure 2 summarizes recall completion rates by vehicle model year for all light vehicle manufacturers. The summary shows a general trend in which newer model year vehicles are more likely to be remedied than vehicles from older model years.[8] For example, a recall issued in 2013 for the 2013 Toyota Camry (when the vehicle was still very new) experienced an 88% completion rate. Conversely, a 2003 Toyota Camry recalled in 2013 (when the vehicle was 11 years old) experienced a 37% completion rate.

Figure 2
Completion Rates by Vehicle Model Year, 2012-2016 (5Q recalls)

	Year of Recall				
Model Year	**2012**	**2013**	**2014**	**2015**	**2016**
1986		50.0%			
1989				0.6%	
1994		33.7%			
1997			18.1%	33.1%	
1998	22.5%			21.5%	
1999	34.5%				
2000			57.8%	3.1%	
2001	36.9%		39.6%	57.5%	1.6%
2002	40.7%	28.5%	33.7%	34.4%	49.8%
2003	55.5%	37.3%	61.2%	25.7%	32.8%
2004	67.3%	45.8%	47.0%	30.7%	1.3%
2005	55.7%	56.3%	48.8%	41.6%	22.4%
2006	60.2%	55.8%	54.2%	42.7%	51.3%
2007	58.2%	58.5%	32.2%	45.6%	47.7%
2008	80.0%	59.8%	67.1%	54.9%	40.7%
2009	72.3%	76.0%	82.3%	52.5%	53.7%
2010	73.1%	72.9%	69.2%	63.8%	67.1%
2011	87.4%	76.2%	72.6%	64.4%	64.1%
2012	85.2%	78.9%	82.4%	70.3%	66.1%
2013	96.0%	87.6%	76.6%	79.6%	72.3%
2014		92.8%	89.2%	83.7%	84.9%
2015			89.9%	85.3%	86.6%
2016				91.4%	82.6%
2017					87.7%
Grand Total	**59.39%**	**59.81%**	**58.34%**	**52.44%**	**67.29%**

[8] When a recall included multiple model years, the Agency used the age of the oldest vehicle in the recall for the model year categorization displayed in Figure 2. Boxes displaying as blank did not involve any model year vehicles in a recall that year.

One potential explanation for the disparity in recall completion rates between older and newer vehicles is the presence of new vehicle warranty programs. Vehicle owners may be more likely to visit a dealership during the warranty period and, as such, would have any outstanding safety recalls performed in the same visit. Figure 2b shows the same model year completion rate data, but grouped in ranges by the age of the oldest vehicle at the time of the recall.

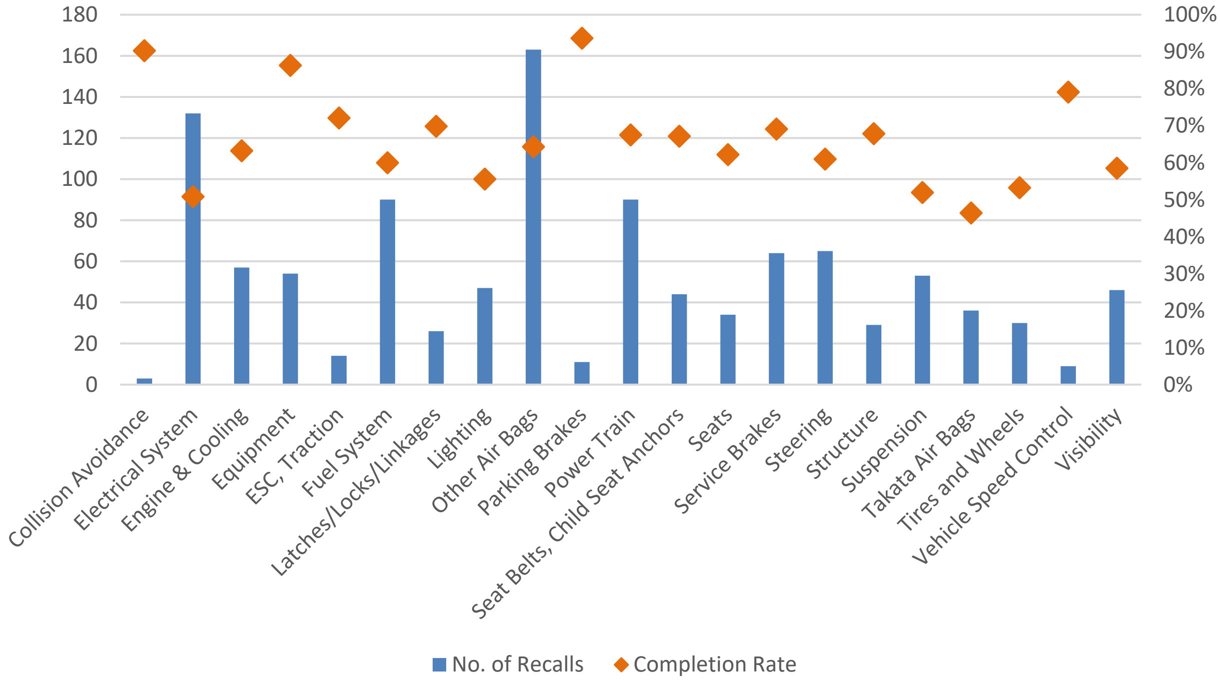
Figure 2b
Completion Rates by Age of Oldest Vehicle, 2012-2016 (5Q recalls)

	Year of Recall					
Oldest Vehicle Age Range	**2012**	**2013**	**2014**	**2015**	**2016**	Grand Total
0-3	82.90%	81.30%	78.61%	80.38%	79.33%	79.78%
4-9	60.53%	58.31%	62.44%	55.29%	60.05%	59.52%
10+	39.18%	35.65%	43.97%	42.00%	42.80%	42.25%
Grand Total	**59.39%**	**59.81%**	**58.34%**	**52.44%**	**67.29%**	58.31%

c. Annual Rates by Component

Figure 3 provides recall completion rates by component category. The recall completion rates for most component categories fall within a range of 60% to 70%. For example, of the over eight million vehicles recalled for “Power Train” issues across 90 recalls, 68% of those vehicles were repaired. Recalls for the component categories “Takata Air Bags” and “Suspension” did not perform as well, with 46% and 52% of vehicles remedied for those issues, respectively. Appendix B provides component category completion rates by recall year. In Figure 3, the number of recalls for each component category is provided on the left-hand y-axis, while the completion rate is displayed on the right-hand y-axis.

Figure 3
Completion Rates by Recalled Component, 2012-2016 (5Q recalls)

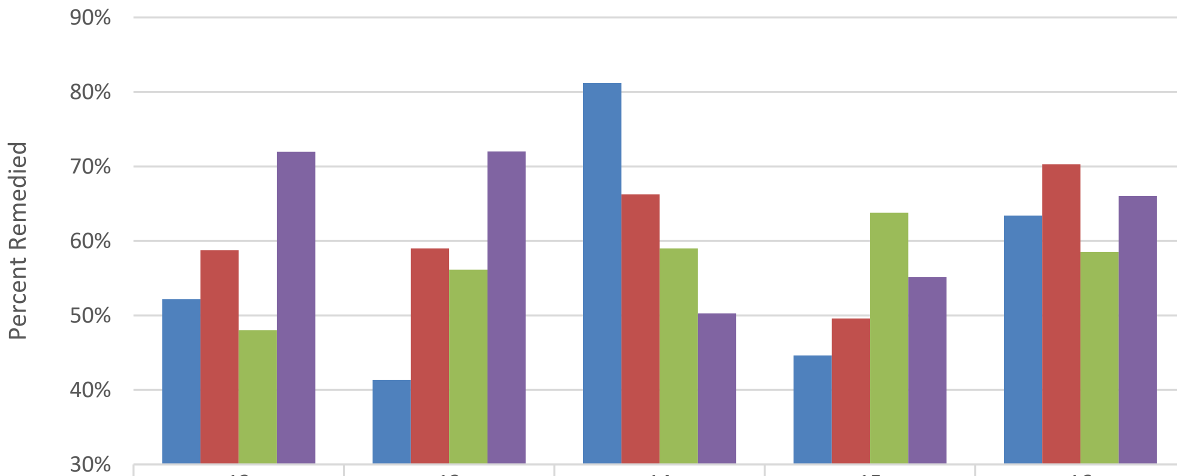


d. Annual Rates by Vehicle Type

Figure 4 depicts annual recall completion rates based on vehicle type. Approximately 18% of recalls include a mix of vehicle types, and those are represented in the "Mix" category. The annual recall completion rate for all vehicles combined ranged between a low of 52% in 2015 to a high of 67% in 2016. Similarly, when examining the light vehicle recall types by year, there can be fairly significant fluctuations. For example, 72% of recalled passenger cars were remedied in 2012, but only 50% in 2014, with an uptick to 66% in 2016.[9]

[9] Recalls for light trucks saw an 81% completion rate in 2014 primarily due to large recalls issued by General Motors for very new vehicles.

Figure 4
Completion Rates by Vehicle Mix, 2012-2016 (5Q recalls)



	12	13	14	15	16
L. Truck	52.19%	41.33%	81.19%	44.63%	63.40%
Mixed	58.76%	59.00%	66.25%	49.59%	70.29%
MPV	48.02%	56.13%	59.00%	63.78%	58.53%
Pass. Car	71.96%	72.01%	50.27%	55.14%	66.04%

V. RECALL COMPLETION TRENDS AND SIGNIFICANT FACTORS

This report to Congress analyzes recall completion rates with respect to two objectives:

1) To identify factors that have a statistical impact on recall completion rates; and

2) To produce a model of benchmarks for future recall completion rates.

The results of this analysis are presented below.

a. Data Used

In order to try to get as accurate a statistical model as possible, NHTSA used more recall data than the 1,097 recalls used in Section IV. Specifically, the Agency used the 1,395 mature light vehicle recalls that were initiated during 2010-2016. (Section IV used 2012-2016).

Approximately 53% of the recalls analyzed in this report included vehicles from multiple model years.[10] As noted in Section III of this report, NHTSA does not receive a detailed itemization of recalled vehicles by model year, only an overall total. For recalls that included vehicles in multiple model years, only the oldest model year was considered in development of the model.

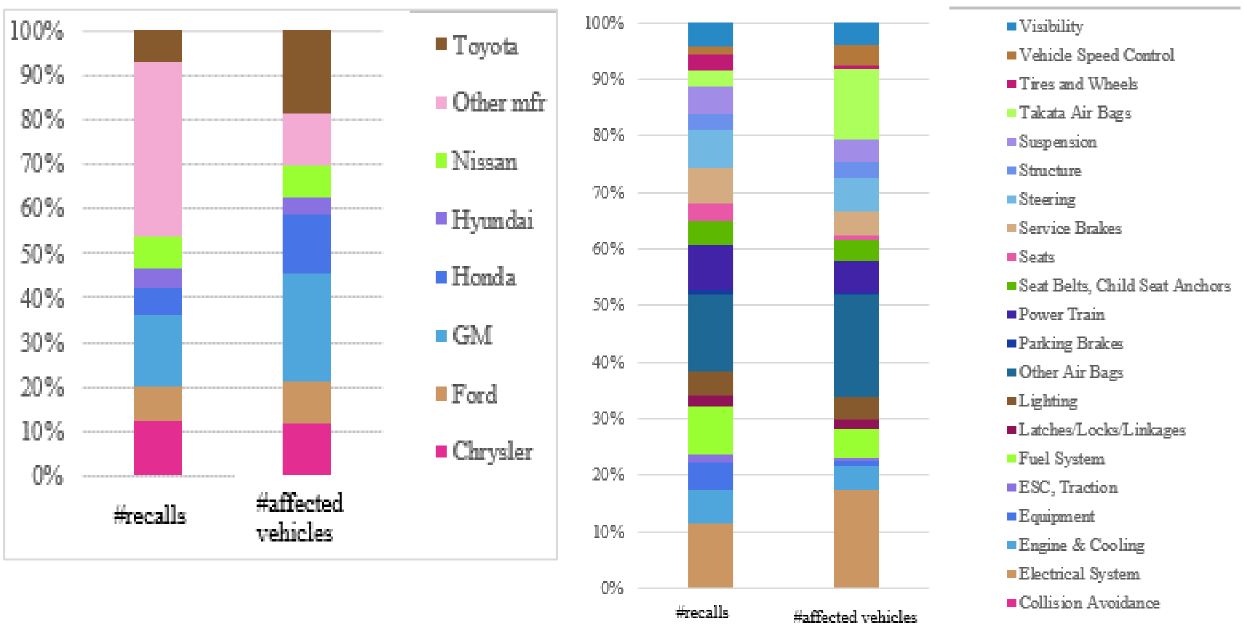
Approximately 13% of the recalls identified more than one defective component. To avoid the complications that would arise from considering multiple components, only the first listed component for these recalls was considered in the model.

b. Exploratory Analysis and Data Visualization

First, an exploratory analysis was conducted on the 1,395 light vehicle recalls conducted between 2010 and 2016. Figure 5 provides an overview of which manufacturers issued the most recalls in this period and how many recalls were issued. Figure 5 also illustrates the number of vehicles recalled and the number of recalls by component type.

[10] Because NHTSA lacks a breakdown of the number of affected vehicles by model year, NHTSA cannot compute the average age among affected vehicles.

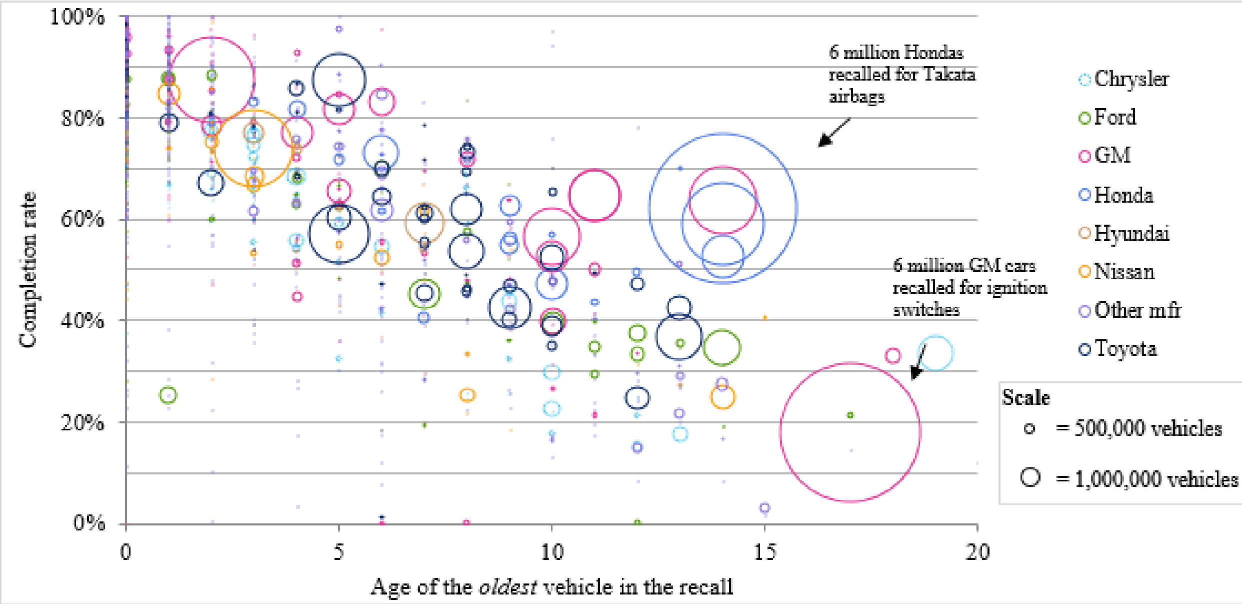
Figure 5
Numbers of Recalls and Affected Vehicles by Manufacturer and Component



Totals: 1,395 recalls, affecting 176,586,581 vehicles

Figure 6 depicts how vehicle age (based on the oldest vehicle involved in a given recall) correlates with recall completion rates. The bubbles presented in Figure 6 are scaled according to the number of vehicles involved in the recall. The seven manufacturers identified in Figure 6 all conducted a recall involving more than 1 million vehicles between 2010 and 2016. Figure 6 shows a general downward trend in recall completion rates as the age of the recalled vehicles increases. Generally, recalls involving newer vehicles have higher recall completion rates than recalls involving older vehicles. The two labeled, large bubbles to the right of the chart represent six million Honda vehicles recalled for Takata air bags in 2015 and another six million General Motors vehicles recalled for ignition switch defects in 2014. Together, these two recalls affected more than 12 million vehicles, and some affected vehicles were up to 18 years old.

Figure 6
Recall Completion Rate by Age of Oldest Vehicle and Manufacturer



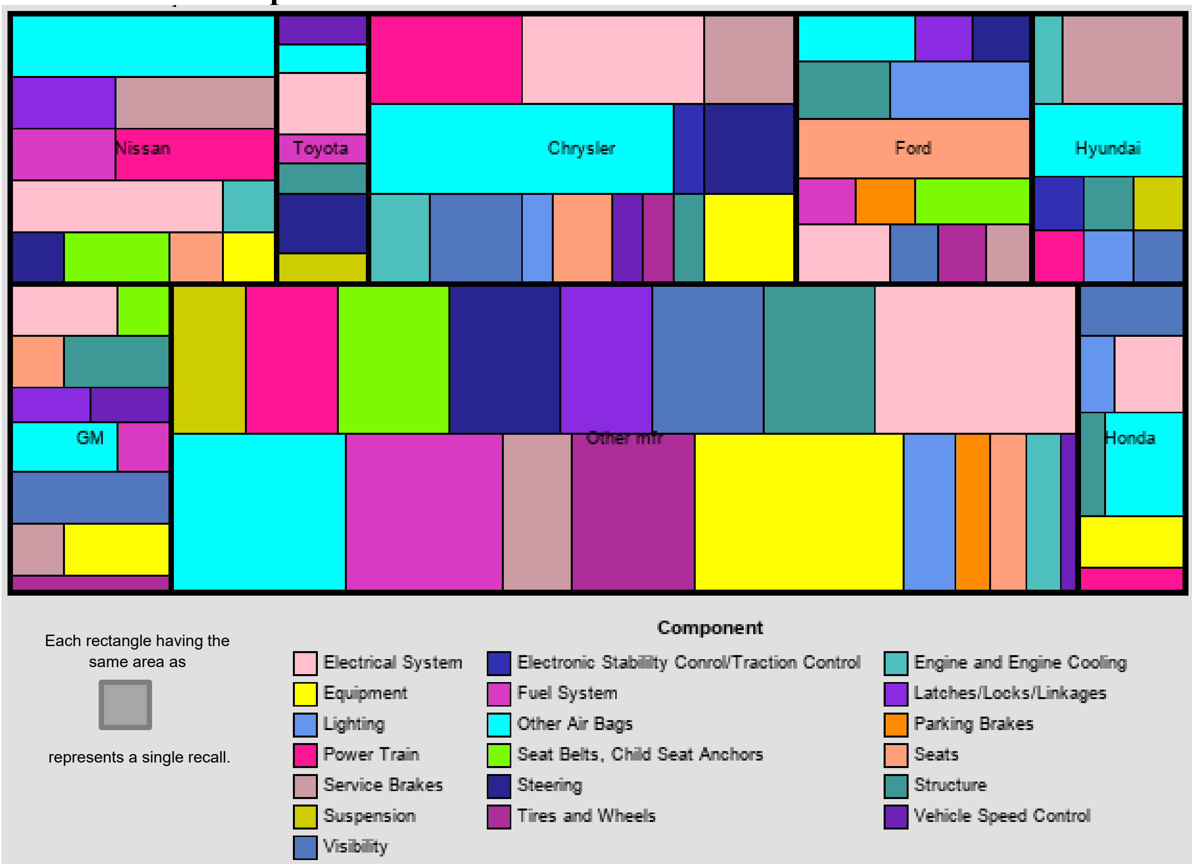
Of the 1,395 recalls examined in creating this model:

- 1,070 recalls (77%) were for vehicles four years of age or less when the recall was issued.
- 246 of these (23% of 1,070) had completion rates less than 75%.

As noted above, recalls involving these newer vehicles should have a relatively high recall completion rate, so it bears noting which recalls underperformed.

Figure 7 illustrates the component categories identified in these recalls with a completion rate less than 75% and when the involved vehicles were four years old or less. These selections were chosen because a completion rate of 75% is generally an average completion rate, and recalls affecting newer vehicles are generally considered to perform higher than average. Also, most new vehicle warranties last three to five years and owners may be more inclined to have their recalls remedied while still under warranty. While air bag recalls appear to be prominent for a few manufacturers shown in Figure 7 (such as Chrysler (FCA) and Nissan), a variety of component categories are identified in these under-performing recalls.

Figure 7
Recall Completion Rates Under 75% for Vehicles Less than 5 Years Old



c. Potential Factor Identification and Model Introduction

When examining the multiple variables associated with safety recalls, the Agency considered eleven factors for potential inclusion in the model:

1. The manufacturer;
2. The age of the oldest affected vehicle;
3. The vehicle type involved (i.e., passenger cars, lights trucks, MPVs);
4. The component category;
5. The recall safety risk description includes the word “crash”;
6. The recall safety risk description includes the word “fire”;

7. The recall safety risk description includes the word "death";
8. The recall safety risk description includes the word "injury";
9. The recall safety risk description includes the word "serious";
10. The year the recall was initiated; and
11. The number of vehicles affected by the recall.

NHTSA considered several families of statistical models, including a variety of generalized linear models. The Agency applied both stepwise and LASSO (Least Absolute Shrinkage and Selection Operator) effect selection methods, and selected the final model via cross-validation. The result of this process was a fixed-effects logistic regression model with a Williams adjustment for over-dispersion, namely:

$$\ln \frac{r}{1-r} \sim \text{Age, Component, Manufacturer*Component} \qquad (1)$$

In this model, r denotes the recall completion rate.[11] This is the predictive model NHTSA used to assess each factor's relative impact and to aid in projecting recall completion rates for future recalls. All 176,586,581 vehicles involved in recalls during the 2010-2016 time frame contributed equally to the model. Figure 8, located in Appendix D, presents standard statistical details for the model, including parameter estimates and standard errors.

d. Model Fit with Recall Completion Rates

Figure 9 illustrates the model. Every data point indicates a separate recall. The figure shows that NHTSA's model generally fits the data, but it is not a perfect predictor of recall completion rates due to the limited data that NHTSA is able to collect, as previously discussed, and the inherently imperfect nature of modeling. When the 1,395 light vehicle recalls from 2010 through

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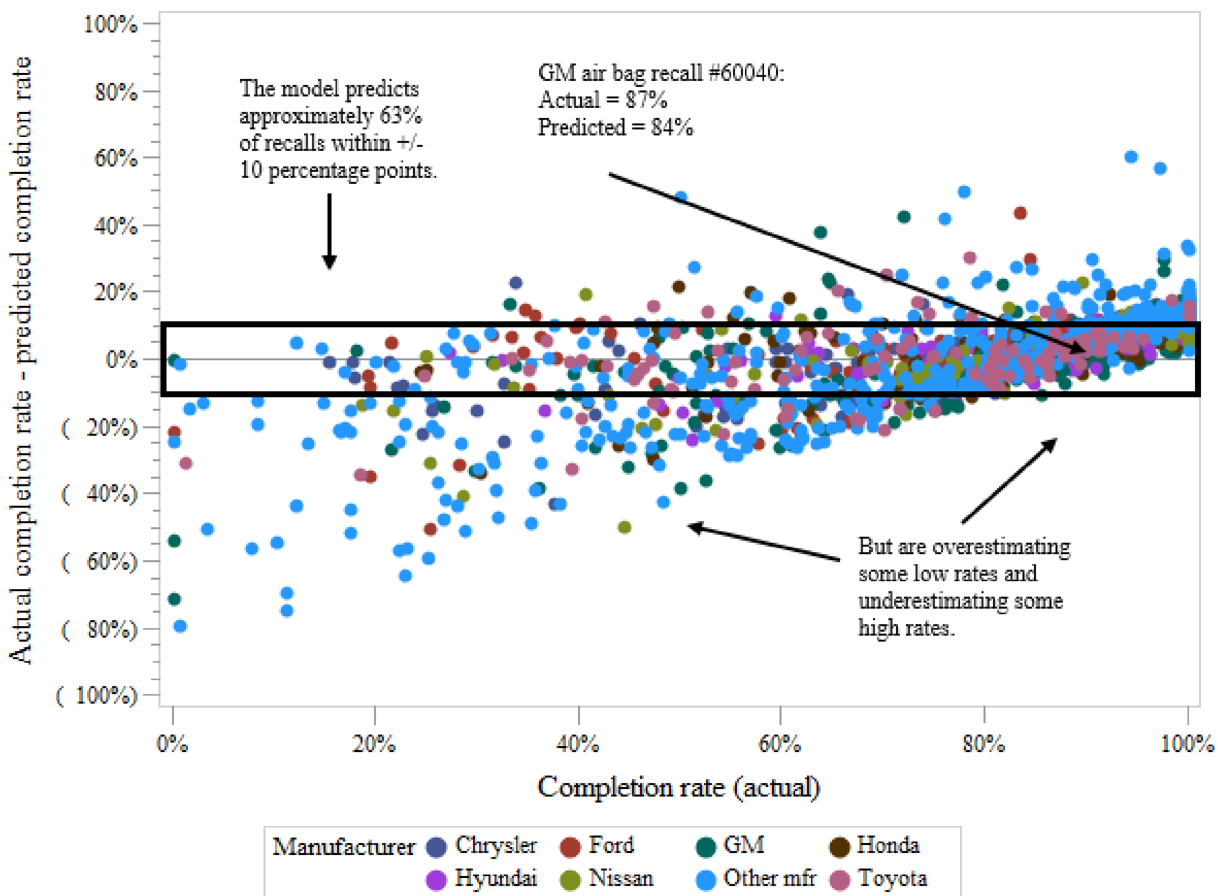
[11] For further information on these types of models, effect selection, model selection, and the notation in Equation (1), NHTSA refers the reader to the following reference: SAS Institute Inc. 2017. *SAS/STAT® 14.3 User's Guide*. Cary, NC: SAS Institute Inc.

2016 were analyzed, the model predicted the correct completion rate for 63% of those recalls, within plus or minus 10 percentage points. The model fit best for the "major" manufacturers, such as those found on NHTSA's VIN Look-up Tool. For these major manufacturers, the model correctly predicted 73% of recall completion rates within plus or minus 10 percentage points. On the other hand, many of the recalls where the predicted completion rates were off by more than 10 percentage points involved smaller manufacturers (labeled as "Other" in Figure 9).

Figure 9. Model Fit at Predicting Recall Completion Rates

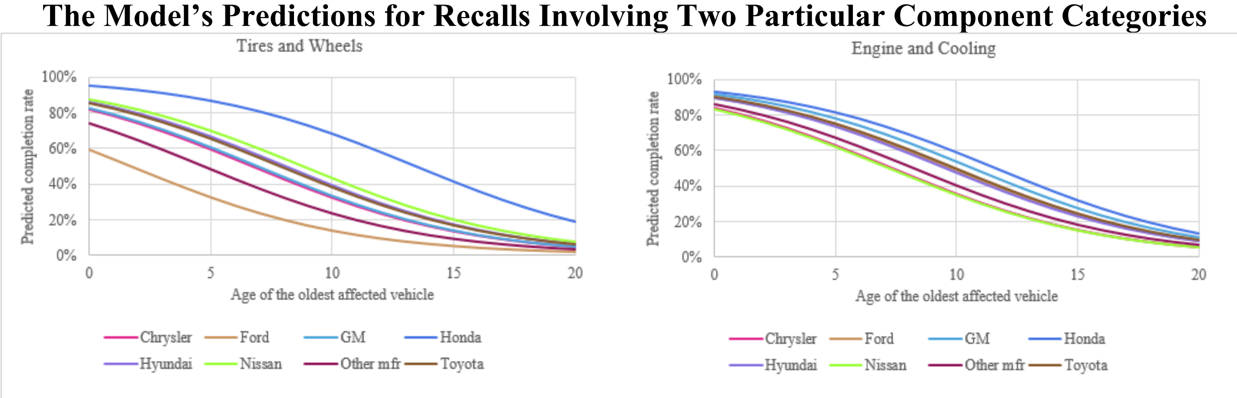


e. Model Results and Most Significant Factors

NHTSA's model involves only three significant factors – vehicle age, component, and manufacturer.[12] Appendix C contains all 21 graphs, and two of them are illustrated here: Tires and Wheels, and Engine and Cooling.

The leftmost panel in Figure 10 depicts the model's predictions for recalls involving tires and wheels, while the right panel does the same for recalls involving engines and engine cooling. The model predicts recalls for tires and wheels on brand new vehicles (age 0) to have completion rates of 59% to 95% depending on the manufacturer. By the time these vehicles are 20 years old, their completion rates fall to between 2% and 19%, again depending on the manufacturer. In contrast, the model predicts the completion rates for engine and engine cooling systems to have less variability by manufacturer, starting at 83% to 93% at age 0 and falling to 5 to 13% at age 20 years. While the model predicts Honda to have the highest completion rates for both component categories, it predicts different lower performers, with Toyota being lower for recalls involving tires and wheels and Nissan lowest for recalls involving engine and cooling issues.

Figure 10
The Model's Predictions for Recalls Involving Two Particular Component Categories



[12] NHTSA also considered other potential factors such as the size of the recall, words such as "fire" or "crash" or "death" used in the safety risk description, and the year the recall was initiated. However, these factors did not have a significant statistical effect and, as such, were not used in NHTSA's model.

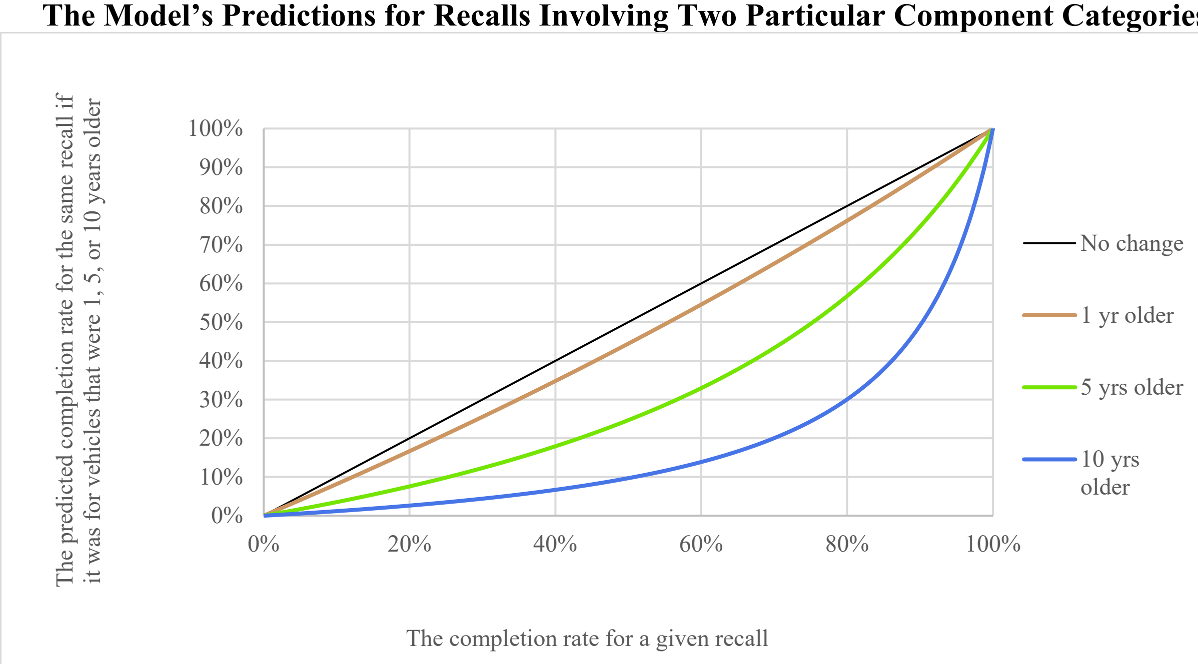
In this model the effect of manufacturer varies by component. This effect is illustrated in Figure 10, where the manufacturer with the lowest recall completion rate differed between the two component categories.

The model shows three scenarios to have statistically significant effects on completion rates, namely:

1) The age of the oldest affected vehicle,
2) 38 differences between manufacturers for particular components, and
3) 127 differences between components for particular manufacturers.

One way to understand the effect of age on completion rates is through the following graph, which shows the effect of increasing the age of the oldest vehicle in the recall by one, five, or ten years, keeping all other characteristics of the recall the same.

Figure 11
The Model's Predictions for Recalls Involving Two Particular Component Categories



The graph indicates the effect of vehicle age, with a 5-year increase in age reducing a completion rate of 80% to below 60%. Note, however, that the data available to NHTSA cannot indicate the extent to which the vehicle age effect is truly a function of age or whether other factors—such as the demographics of owners of new vehicles or new vehicle warranty programs—play a significant role.

The model identifies 38 statistically significant differences[13] between manufacturers for particular components. For instance, Chrysler (FCA) has a statistically higher completion rate for parking brakes than the collective "Other manufacturers" for vehicles of the same age. This is illustrated in the first line of Figure 12.

Figure 12
Statistically Significant Differences between Manufacturers for Particular Components

Manufacturer with the higher completion rate	***Manufacturer with the lower completion rate***	***The component for which the relationship holds***
Chrysler	Other mfr	Parking Brakes
GM	Chrysler	Other Air Bags
GM	Chrysler	Power Train
GM	Chrysler	Seats
GM	Ford	Other Air Bags
GM	Ford	Parking Brakes
GM	Ford	Seats
GM	Honda	Visibility
GM	Hyundai	Other Air Bags
GM	Hyundai	Suspension
GM	Nissan	Other Air Bags
GM	Nissan	Suspension
GM	Other mfr	Electrical System

[13] The data to which the model was fit is a census (of all light vehicle recalls initiated during 2010-2016), and so the "statistical significance" here does not refer to sampling significance. Rather, it refers to significance in the model. For instance, in the Chrysler example, this means that controlling for vehicle age, the difference between Chrysler's and the other manufacturers' completion rates for parking brakes is higher than the Agency would expect to see under ordinary binomial variation (modeling the number of remedied vehicles for each manufacturer, component, and vehicle vintage as binomially distributed from the number of affected vehicles (number of trials) and a "true" completion rate).

GM	Other mfr	Other Air Bags
GM	Other mfr	Parking Brakes
GM	Other mfr	Suspension
GM	Toyota	Suspension
Honda	Chrysler	Seats
Honda	Chrysler	Takata Air Bags
Honda	Ford	Parking Brakes
Honda	Ford	Seats
Honda	Ford	Takata Air Bags
Honda	Nissan	Seat Belts, Child Seat Anchors
Honda	Nissan	Takata Air Bags
Honda	Other mfr	Parking Brakes
Honda	Other mfr	Takata Air Bags
Honda	Toyota	Lighting
Honda	Toyota	Takata Air Bags
Nissan	Chrysler	Equipment
Nissan	Ford	Parking Brakes
Nissan	Honda	Equipment
Nissan	GM	Structure
Nissan	Other mfr	Parking Brakes
Other mfr	Toyota	Lighting
Toyota	Ford	Parking Brakes
Toyota	Ford	Tires and Wheels
Toyota	Nissan	Seat Belts, Child Seat Anchors
Toyota	Other mfr	Parking Brakes

The model also identifies 127 statistically significant differences between components for particular manufacturers. These are listed in Appendix E.

VI. SUMMARY OF FINDINGS

Based on the recall completion analysis provided in section IV and the statistical analysis that controlled for certain factors in section V, NHTSA made the following findings:

- 58% of vehicles recalled by major, light vehicle manufacturers between 2012 and 2016 were remedied by the fifth quarter of the recall. The lowest recall completion rate during this period was 52% in 2015, and the highest recall completion rate was 67% in 2016.

• The age of the recalled vehicle plays a significant role in recall completion. Recalls for newer vehicles tend to have higher completion rates than recalls for older vehicles. For instance, increasing the age of the oldest vehicle in a given recall by 5 years could be expected to reduce a completion rate of 80% to below 60%.

• The model identified 38 scenarios where one manufacturer had a higher completion rate than another for a particular component, and the difference in completion rates was statistically significant. For instance, Chrysler (FCA) had a statistically higher completion rate for parking brake recalls than other manufacturers for vehicles of the same age.

• Likewise, the model identified 127 scenarios where a particular manufacturer had statistically higher completion rates for one component versus another, controlling for vehicle age. For instance, Chrysler (FCA) had a statistically higher completion rate for recalls involving steering issues than recalls for electrical systems, for vehicles of the same age.

- NHTSA's model predicts 63% of recall completion rates accurately within a 10-percentage-point margin of error and predicts 73% of rates accurately for major manufacturers. This suggests that other factors relevant to recall completion rates are present but not identifiable with the available data.

VII. ACTIONS TO IMPROVE RECALL COMPLETION RATES

NHTSA strives each day to improve the safety recall process and to ensure as many owners as possible seek remedies for recalled vehicles. More specifically, the Agency is taking these actions or is evaluating these potentialities:

1) Development of predictive modeling guided by the statistical analysis in this report, particularly the significant findings noted above. This modeling will allow the Agency to better identify, with more expediency and accuracy, under-performing recalls and to work with manufacturers to improve their rates. It will also allow for identification of successful recalls and closer examination of the reason(s) for their relative success as compared to peer recalls.

A new system, the Recall Case Manager (RCM), will be deployed to ensure greater scrutiny of the recalls universe. The benchmarking task within RCM will utilize the statistical model detailed in this report for recalls meeting various NHTSA criteria. As model improvements are made, the benchmarking task within RCM will be updated accordingly.

2) Continued facilitation of sharing of information, such as best practices and lessons learned, for improving recalls completion. The continued oversight of the Takata recalls and the first-of-its kind coordinated remedy approach in particular, is expected to continue to inform the Agency, and then by extension, various automotive manufacturers and equipment suppliers that conduct or are otherwise directly involved in the execution of safety recalls. NHTSA's "Tactical Tips" document has recently consolidated some of these learnings and is currently being distributed to relevant parties.

Appendix A: Annual Recall Completion Rates by Vehicle Manufacturer

The table below provides the annual recall completion rate for manufacturers recalling light vehicles between 2012 and 2016. This table includes companies that modify new motor vehicles before their first retail sale (vehicle alterers), certain manufacturer distributors, and some low-volume, specialty manufacturers (such as limousine builders or electric vehicle manufacturers).

Manufacturer	2012	2013	2014	2015	2016	Total
Aston Martin, The Americas	68.2%		72.9%	73.0%		72.9%
Automobili Lamborghini	54.5%					54.5%
Automobili Lamborghini America LLC		50.4%				50.4%
Bentley Motors, Inc.		69.5%		78.7%	22.8%	77.3%
BMW of North America, LLC	75.1%	77.0%	40.6%	37.5%	61.3%	57.9%
Braun Corporation	95.0%	70.9%		99.9%	35.3%	90.5%
Bugatti					95.6%	95.6%
Chrysler (FCA US LLC)	44.9%	51.5%	59.3%	56.5%	64.1%	56.3%
Eldorado National-Kansas		66.2%		52.2%	28.1%	41.8%
Explorer Van Company, Inc.		25.2%				25.2%
Ferrari North America, Inc.	98.6%		72.8%	89.1%		77.6%
Fisker Automotive Incorporated	95.9%					95.9%
Ford Motor Company	52.7%	70.3%	62.8%	57.2%	23.1%	58.4%
Freedom Motors, Inc.			31.5%			31.5%
General Motors LLC	74.4%	78.0%	55.7%	49.8%	84.0%	60.6%
Gulf States Toyota, Inc.	88.4%		78.4%	61.8%	92.8%	79.2%
Honda (American Honda Motor Co.)	53.6%	68.1%	62.0%	61.6%	53.8%	60.2%
Hyundai Motor America	66.2%	60.7%	67.9%	68.1%	70.3%	65.4%
Isuzu Technical Center of America, Inc.	8.3%	17.5%				11.7%
Jaguar Land Rover North America, LLC	85.3%	77.2%	76.4%	64.0%	86.7%	68.7%
Kia Motors America	48.8%	63.5%	66.6%	71.3%	52.5%	62.7%
Lotus Cars USA, Inc.	81.3%	40.3%	31.7%			37.5%
Maserati North America, Inc.	82.5%	66.9%	100.0%	87.8%	84.2%	82.3%
Mazda Motor Corp.	37.0%					37.0%
Mazda North American Operations	40.5%	56.1%	45.4%	9.0%	42.8%	26.0%
McLaren Automotive Incorporated		82.4%		93.4%		85.1%
Mercedes-Benz USA, LLC - DBA Sprinter			79.3%	70.2%		75.2%
Mercedes-Benz USA, LLC.	87.5%	88.3%	68.0%	77.1%	89.1%	73.6%

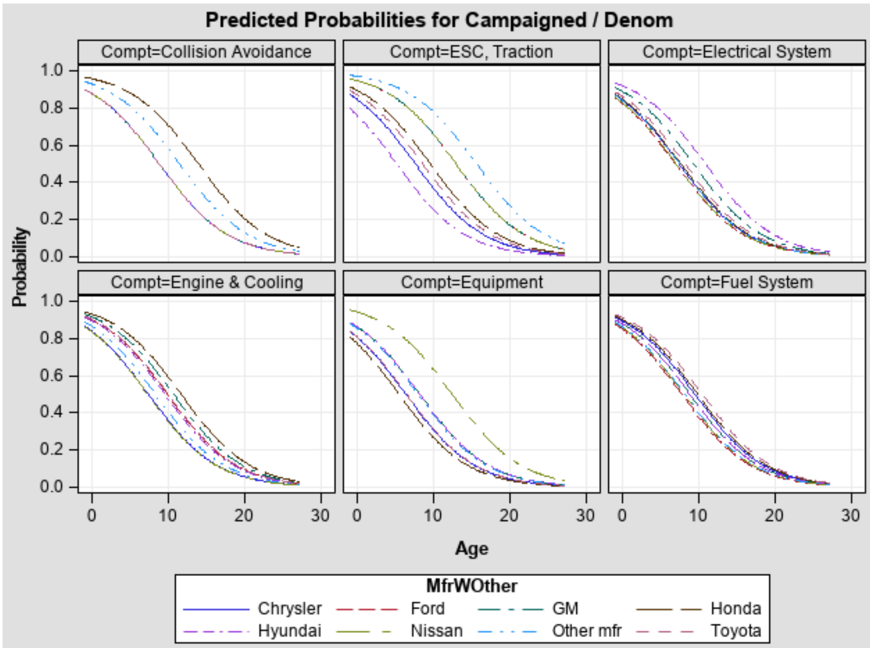
Mitsubishi Motors North America, Inc.	95.0%	66.6%	47.7%	21.4%	40.1%	32.3%
Nissan North America, Inc.	82.0%	82.1%	82.5%	50.6%	72.3%	67.9%
Oreion Motors LLC.		22.3%				22.3%
Polaris Industries, Inc.		37.6%		25.8%	75.8%	42.5%
Porsche Cars North America, Inc.	73.6%	89.8%	84.7%	82.8%	77.5%	78.1%
Rolls-Royce Motor Cars, Ltd.	92.4%	100.0%				94.3%
Roush Performance Products, Inc.				22.8%		22.8%
Southeast Toyota Distributors, LLC		84.7%	47.6%	55.1%	48.0%	60.7%
Subaru of America, Inc.	69.5%	57.8%	52.9%	29.0%	58.3%	53.7%
Suzuki Motor of America, Inc.	22.6%	28.4%	27.0%	54.1%		27.5%
Tesla, Inc.		88.3%	98.5%	91.1%	97.1%	93.1%
Toyota Motor Engineering & Manufacturing	62.1%	52.1%	58.6%	40.3%	53.7%	52.6%
US Specs		40.0%				40.0%
Volkswagen Group of America, Inc.	91.8%	87.8%	76.1%	79.2%	64.0%	76.7%
Volvo Car USA LLC	97.6%	90.0%		97.8%	96.5%	94.8%
Westward Industries			100.0%			100.0%

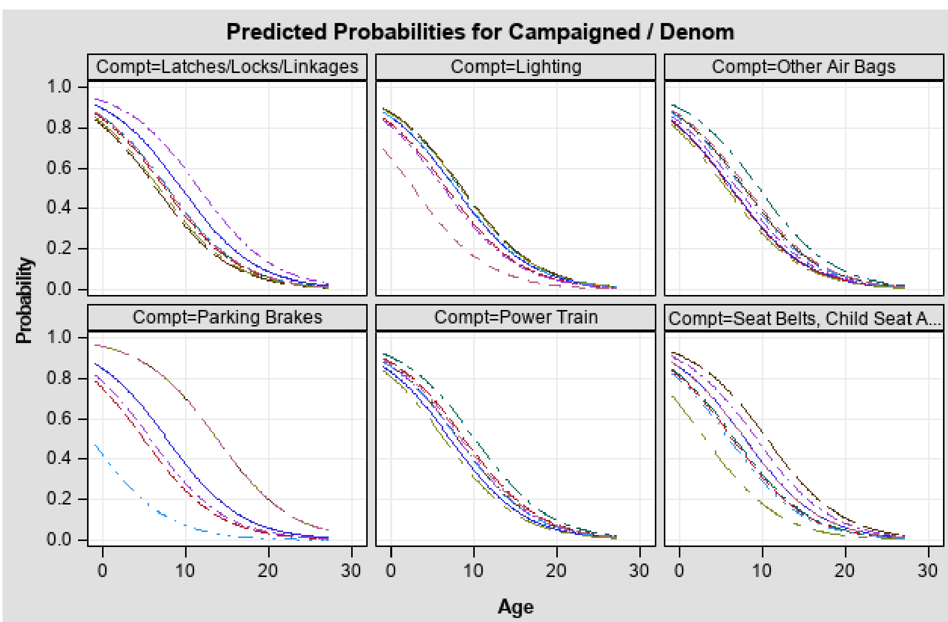
Appendix B: Annual Recall Completion Rates by Component

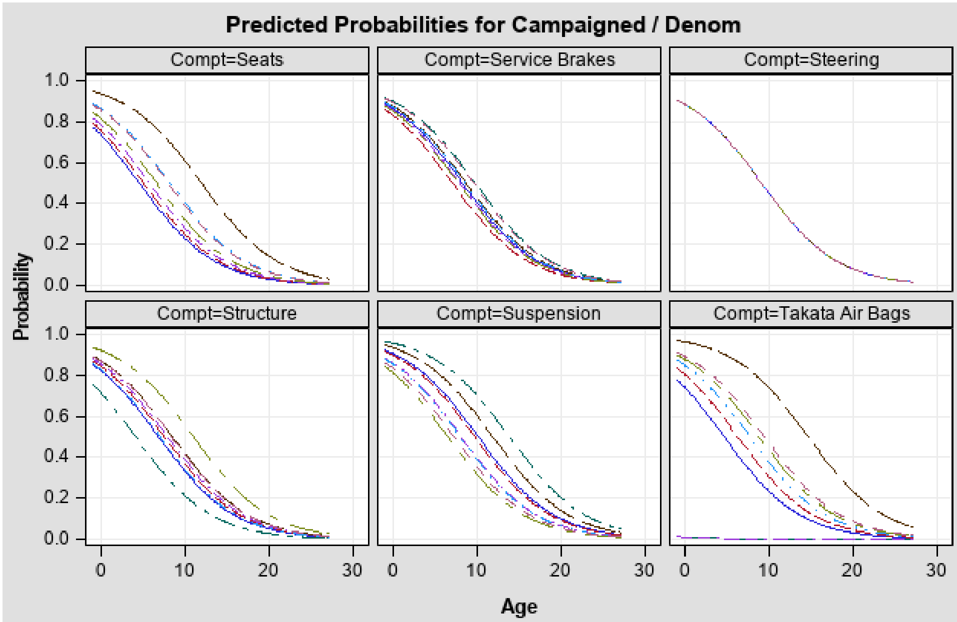
Component Category	2012	2013	2014	2015	2016
Collision Avoidance				90.3%	
Electrical System	58.5%	73.5%	48.3%	43.7%	69.5%
Engine & Cooling	65.0%	85.8%	78.9%	50.9%	92.7%
Equipment	98.9%	86.9%	65.6%	90.1%	89.2%
ESC, Traction		71.5%	82.0%	62.7%	89.3%
Fuel System	76.2%	47.2%	63.2%	72.3%	79.9%
Latches/Locks/Linkages	76.2%	58.8%	77.4%	72.3%	65.4%
Lighting	54.8%	57.0%	52.9%	51.3%	79.6%
Other Air Bags	44.8%	64.4%	67.1%	45.5%	76.4%
Parking Brakes	84.5%	65.9%	96.1%	82.6%	
Power Train	60.5%	63.4%	68.6%	69.4%	71.7%
Seat Belts, Child Seat Anchors	69.6%	46.8%	80.9%	61.9%	64.1%
Seats	87.0%	43.7%	63.9%	91.8%	47.5%
Service Brakes	42.9%	75.1%	70.6%	60.4%	81.6%
Steering	65.6%	41.9%	61.5%	69.3%	76.2%
Structure	74.4%	93.1%	63.9%	72.4%	59.5%
Suspension	64.9%	51.2%	53.3%	33.7%	39.3%
Takata Air Bags		28.5%	35.7%	48.5%	40.4%
Tires and Wheels	35.1%	85.3%	49.3%	83.7%	55.7%
Vehicle Speed Control	81.0%	63.0%	85.9%	83.3%	83.0%
Visibility	60.1%	60.3%	68.1%	51.5%	71.6%

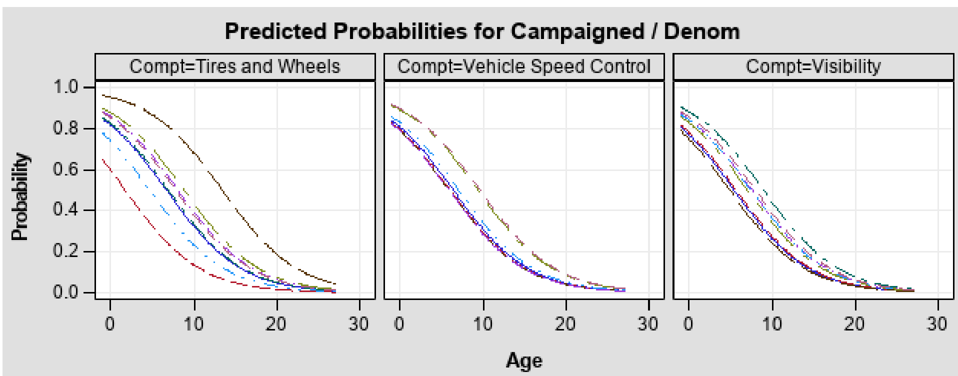
Appendix C

Below are charts depicting the completion rate model. There is one chart (panel) for each component category in the model.






Predicted Probabilities for Campaigned / Denom
Compt=Seats
Compt=Service Brakes
Compt=Steering
Compt=Structure
Compt=Suspension
Compt=Takata Air Bags
Probability
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
Age


Predicted Probabilities for Campaigned / Denom
Compt=Tires and Wheels
Compt=Vehicle Speed Control
Compt=Visibility
Probability
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
Age

Appendix D

The following table presents the coefficients for the Williams-adjusted fixed effect logistic model used in Section V.

Figure 8
Parameter Estimates for the Logistic Model of Completion Rates

Variable	*Class Value 0*	*Class Value 1*	*df*	*Estimate*	*Standard Error*	*Wald Chi-Square*	*Prob > Wald Chi-Square*
Intercept			1	2.012	0.101	398.728	0.000
Age			1	-0.223	0.008	860.050	0.000
Component	Collision Avoidance		1	-0.065	0.933	0.005	0.944
	ESC, Traction		1	0.854	0.898	0.906	0.341
	Electrical System		1	0.048	0.186	0.067	0.796
	Engine & Cooling		1	0.355	0.378	0.878	0.349
	Equipment		1	-0.203	0.351	0.333	0.564
	Fuel System		1	-0.058	0.278	0.044	0.833
	Latches/Locks/Linkages		1	-0.298	0.554	0.290	0.590
	Lighting		1	-0.162	0.428	0.142	0.706
	Other Air Bags		1	0.105	0.207	0.255	0.613
	Parking Brakes		1	1.042	0.690	2.284	0.131
	Power Train		1	0.217	0.280	0.601	0.438
	Seat Belts, Child Seat Anchors		1	-0.535	0.233	5.284	0.022
	Seats		1	0.636	0.505	1.585	0.208
	Service Brakes		1	0.149	0.282	0.281	0.596
	Structure		1	-1.117	0.396	7.953	0.005
	Suspension		1	1.057	0.502	4.433	0.035
	Takata Air Bags		1	-6.595	8.642	0.582	0.445
	Tires and Wheels		1	-0.469	0.473	0.982	0.322
	Vehicle Speed Control		1	-0.699	0.592	1.395	0.238
	Visibility		1	-0.015	0.256	0.003	0.953
Mfr * Component	Chrysler	Collision Avoidance	0	0			
		ESC, Traction	1	-1.190	1.008	1.393	0.238
		Electrical System	1	-0.418	0.220	3.613	0.057
		Engine & Cooling	1	-0.739	0.512	2.088	0.148
		Equipment	1	-0.405	0.463	0.765	0.382
		Fuel System	1	0.146	0.569	0.066	0.798
		Latches/Locks/Linkages	1	0.382	1.018	0.141	0.707
		Lighting	1	-0.137	0.636	0.047	0.829
		Other Air Bags	1	-0.727	0.230	10.039	0.002
		Parking Brakes	1	-1.352	0.996	1.844	0.175
		Power Train	1	-0.661	0.317	4.352	0.037
		Seat Belts, Child Seat Anchors	1	0.268	1.113	0.058	0.810
		Seats	1	-1.652	0.674	6.000	0.014
		Service Brakes	1	-0.335	0.411	0.667	0.414
		Structure	1	0.612	0.601	1.038	0.308
		Suspension	1	-0.825	0.685	1.452	0.228
		Takata Air Bags	1	5.607	8.655	0.420	0.517
		Tires and Wheels	1	-0.053	0.630	0.007	0.933

	Vehicle Speed Control	1	0.114	0.763	0.022	0.881
	Visibility	1	-0.799	0.464	2.962	0.085
Ford	Collision Avoidance	0	0			
	ESC, Traction	0	0			
	Electrical System	1	-0.527	0.357	2.175	0.140
	Engine & Cooling	1	-0.185	0.591	0.098	0.755
	Equipment	0	0.000	0.000	0.000	0.000
	Fuel System	1	-0.236	0.329	0.516	0.472
	Latches/Locks/Linkages	1	-0.064	0.717	0.008	0.929
	Lighting	1	-0.373	0.551	0.459	0.498
	Other Air Bags	1	-0.766	0.358	4.572	0.032
	Parking Brakes	1	-1.978	0.897	4.866	0.027
	Power Train	1	-0.274	0.404	0.459	0.498
	Seat Belts, Child Seat Anchors	1	-0.062	0.461	0.018	0.894
	Seats	1	-1.537	0.584	6.926	0.008
	Service Brakes	1	-0.602	0.598	1.013	0.314
	Structure	1	0.767	0.489	2.460	0.117
	Suspension	1	-0.922	0.643	2.054	0.152
	Takata Air Bags	1	5.967	8.651	0.476	0.490
	Tires and Wheels	1	-1.160	0.693	2.803	0.094
	Vehicle Speed Control	1	0.033	1.060	0.001	0.976
	Visibility	1	-0.740	0.562	1.731	0.188
Honda	Collision Avoidance	1	1.144	1.839	0.387	0.534
	ESC, Traction	1	-0.753	1.075	0.490	0.484
	Electrical System	1	-0.374	0.276	1.836	0.175
	Engine & Cooling	1	0.221	0.753	0.086	0.769
	Equipment	1	-0.608	0.510	1.417	0.234
	Fuel System	1	0.230	0.478	0.232	0.630
	Latches/Locks/Linkages	1	-0.296	1.055	0.079	0.779
	Lighting	1	0.046	0.582	0.006	0.936
	Other Air Bags	1	-0.389	0.304	1.638	0.201
	Parking Brakes	0	0			
	Power Train	1	-0.435	0.416	1.094	0.296
	Seat Belts, Child Seat Anchors	1	0.863	0.734	1.382	0.240
	Seats	0	0			
	Service Brakes	1	-0.236	0.524	0.203	0.652
	Structure	1	0.983	0.676	2.115	0.146
	Suspension	1	-0.439	0.809	0.294	0.588
	Takata Air Bags	1	7.835	8.648	0.821	0.365
	Tires and Wheels	1	1.445	1.738	0.691	0.406
	Vehicle Speed Control	0	0			
	Visibility	1	-0.912	0.453	4.058	0.044
Hyundai	Collision Avoidance	0	0			
	ESC, Traction	1	-1.735	1.147	2.285	0.131
	Electrical System	1	0.346	0.603	0.329	0.566
	Engine & Cooling	1	-0.253	0.670	0.142	0.706
	Equipment	0	0			

	Fuel System	0	0			
	Latches/Locks/Linkages	1	0.856	1.167	0.538	0.463
	Lighting	1	-0.452	0.541	0.696	0.404
	Other Air Bags	1	-0.583	0.293	3.944	0.047
	Parking Brakes	1	-1.793	1.101	2.653	0.103
	Power Train	1	-0.439	0.454	0.935	0.334
	Seat Belts, Child Seat Anchors	1	0.575	0.825	0.485	0.486
	Seats	1	-1.381	0.914	2.283	0.131
	Service Brakes	1	-0.409	0.444	0.849	0.357
	Structure	1	0.856	0.873	0.963	0.326
	Suspension	1	-1.274	0.625	4.156	0.041
	Takata Air Bags	0	0			
	Tires and Wheels	1	0.254	0.916	0.077	0.781
	Vehicle Speed Control	0	0			
	Visibility	1	-0.322	0.497	0.419	0.517
Nissan	Collision Avoidance	0	0			
	ESC, Traction	0	0			
	Electrical System	1	-0.513	0.320	2.570	0.109
	Engine & Cooling	1	-0.761	0.568	1.797	0.180
	Equipment	1	0.947	0.667	2.018	0.155
	Fuel System	1	-0.172	0.359	0.230	0.632
	Latches/Locks/Linkages	1	-0.213	0.689	0.096	0.757
	Lighting	1	0.007	0.944	0.000	0.994
	Other Air Bags	1	-0.872	0.280	9.709	0.002
	Parking Brakes	0	0			
	Power Train	1	-0.818	0.429	3.640	0.056
	Seat Belts, Child Seat Anchors	1	-0.795	0.436	3.320	0.068
	Seats	1	-1.191	0.736	2.619	0.106
	Service Brakes	1	-0.440	0.407	1.169	0.280
	Structure	1	1.540	0.755	4.159	0.041
	Suspension	1	-1.630	0.651	6.264	0.012
	Takata Air Bags	1	6.537	8.660	0.570	0.450
	Tires and Wheels	1	0.419	0.783	0.287	0.592
	Vehicle Speed Control	1	0.778	0.945	0.678	0.410
	Visibility	1	-0.431	0.978	0.195	0.659
Other mfr	Collision Avoidance	1	0.596	1.661	0.129	0.720
	ESC, Traction	1	0.604	1.754	0.119	0.731
	Electrical System	1	-0.414	0.204	4.123	0.042
	Engine & Cooling	1	-0.533	0.392	1.852	0.174
	Equipment	1	-0.051	0.374	0.019	0.891
	Fuel System	1	-0.141	0.289	0.239	0.625
	Latches/Locks/Linkages	1	0.019	0.593	0.001	0.974
	Lighting	1	-0.120	0.447	0.072	0.788
	Other Air Bags	1	-0.441	0.221	3.979	0.046
	Parking Brakes	1	-3.386	0.879	14.837	0.000
	Power Train	1	-0.461	0.311	2.198	0.138

	Seat Belts, Child Seat Anchors	1	-0.158	0.283	0.311	0.577
	Seats	1	-0.833	0.552	2.280	0.131
	Service Brakes	1	-0.267	0.305	0.766	0.381
	Structure	1	0.654	0.441	2.200	0.138
	Suspension	1	-1.308	0.519	6.348	0.012
	Takata Air Bags	1	6.287	8.644	0.529	0.467
	Tires and Wheels	1	-0.508	0.497	1.043	0.307
	Vehicle Speed Control	1	0.263	0.679	0.150	0.699
	Visibility	1	-0.334	0.302	1.223	0.269
Toyota	Collision Avoidance	0	0			
	ESC, Traction	1	-0.972	1.001	0.943	0.332
	Electrical System	1	-0.251	0.403	0.388	0.533
	Engine & Cooling	1	-0.160	0.497	0.104	0.747
	Equipment	1	-0.384	0.592	0.420	0.517
	Fuel System	1	0.361	0.434	0.690	0.406
	Latches/Locks/Linkages	0	0.000	0.000	0.000	0.000
	Lighting	1	-1.271	0.670	3.602	0.058
	Other Air Bags	1	-0.319	0.301	1.121	0.290
	Parking Brakes	0	0			
	Power Train	1	-0.340	0.501	0.461	0.497
	Seat Belts, Child Seat Anchors	1	0.263	0.420	0.393	0.531
	Seats	1	-0.884	0.703	1.581	0.209
	Service Brakes	1	-0.046	0.456	0.010	0.920
	Structure	1	0.966	0.690	1.958	0.162
	Suspension	1	-1.469	0.567	6.707	0.010
	Takata Air Bags	1	6.674	8.648	0.596	0.440
	Tires and Wheels	1	0.199	0.645	0.095	0.758
	Vehicle Speed Control	1	0.837	0.672	1.551	0.213
	Visibility	1	-0.220	0.457	0.232	0.630

Appendix E

The table below lists the 127 statistically significant differences between components for particular manufacturers. For instance, the first line of the table conveys that Chrysler has higher completion rates for steering than for electrical systems, controlling for the age of the oldest vehicle in the recall.

Statistically Significant Difference among Components for Particular Manufacturers

The component with the higher completion rate	***The component with the lower completion rate***	***The manufacturer for which this holds***
Steering	Electrical System	Chrysler
Steering	Other Air Bags	Chrysler
Steering	Power Train	Chrysler
Steering	Seats	Chrysler
Steering	Takata Air Bags	Chrysler
Steering	Visibility	Chrysler
Engine & Cooling	Tires and Wheels	Ford
Equipment	Tires and Wheels	Ford
ESC, Traction	Tires and Wheels	Ford
Fuel System	Tires and Wheels	Ford
Steering	Other Air Bags	Ford
Power Train	Tires and Wheels	Ford
Steering	Seats	Ford
Suspension	Seats	Ford
Structure	Tires and Wheels	Ford
Suspension	Tires and Wheels	Ford
Steering	Tires and Wheels	Ford
Electrical System	Seat Belts, Child Seat Anchors	GM
Electrical System	Structure	GM
Engine & Cooling	Seat Belts, Child Seat Anchors	GM
Engine & Cooling	Structure	GM
Suspension	Equipment	GM
ESC, Traction	Structure	GM
Fuel System	Structure	GM
Suspension	Fuel System	GM
Other Air Bags	Seat Belts, Child Seat Anchors	GM
Other Air Bags	Structure	GM
Parking Brakes	Seat Belts, Child Seat Anchors	GM
Parking Brakes	Structure	GM
Power Train	Seat Belts, Child Seat Anchors	GM
Power Train	Structure	GM
Seats	Seat Belts, Child Seat Anchors	GM
Service Brakes	Seat Belts, Child Seat Anchors	GM
Steering	Seat Belts, Child Seat Anchors	GM
Suspension	Seat Belts, Child Seat Anchors	GM

Seats	Structure	GM
Service Brakes	Structure	GM
Steering	Structure	GM
Suspension	Structure	GM
Visibility	Structure	GM
Suspension	Steering	GM
Suspension	Tires and Wheels	GM
Suspension	Vehicle Speed Control	GM
Suspension	Visibility	GM
Takata Air Bags	Electrical System	Honda
Engine & Cooling	Visibility	Honda
Parking Brakes	Equipment	Honda
Seats	Equipment	Honda
Steering	Equipment	Honda
Takata Air Bags	Equipment	Honda
Takata Air Bags	Fuel System	Honda
Fuel System	Visibility	Honda
Takata Air Bags	Lighting	Honda
Takata Air Bags	Other Air Bags	Honda
Parking Brakes	Visibility	Honda
Takata Air Bags	Power Train	Honda
Seats	Visibility	Honda
Takata Air Bags	Service Brakes	Honda
Takata Air Bags	Structure	Honda
Suspension	Visibility	Honda
Takata Air Bags	Steering	Honda
Takata Air Bags	Vehicle Speed Control	Honda
Takata Air Bags	Visibility	Honda
Steering	Visibility	Honda
Parking Brakes	Electrical System	Nissan
Equipment	Other Air Bags	Nissan
Equipment	Power Train	Nissan
Equipment	Seat Belts, Child Seat Anchors	Nissan
ESC, Traction	Seat Belts, Child Seat Anchors	Nissan
Fuel System	Seat Belts, Child Seat Anchors	Nissan
Parking Brakes	Other Air Bags	Nissan
Steering	Other Air Bags	Nissan
Parking Brakes	Power Train	Nissan
Parking Brakes	Seat Belts, Child Seat Anchors	Nissan
Parking Brakes	Suspension	Nissan
Service Brakes	Seat Belts, Child Seat Anchors	Nissan
Steering	Seat Belts, Child Seat Anchors	Nissan
Structure	Seat Belts, Child Seat Anchors	Nissan
Electrical System	Parking Brakes	Other mfr
Steering	Electrical System	Other mfr
Electrical System	Tires and Wheels	Other mfr
Engine & Cooling	Parking Brakes	Other mfr
Engine & Cooling	Seat Belts, Child Seat Anchors	Other mfr

Engine & Cooling	Tires and Wheels	Other mfr
Equipment	Parking Brakes	Other mfr
Equipment	Tires and Wheels	Other mfr
ESC, Traction	Parking Brakes	Other mfr
Fuel System	Parking Brakes	Other mfr
Fuel System	Seat Belts, Child Seat Anchors	Other mfr
Fuel System	Tires and Wheels	Other mfr
Latches/Locks/Linkages	Parking Brakes	Other mfr
Latches/Locks/Linkages	Tires and Wheels	Other mfr
Lighting	Parking Brakes	Other mfr
Lighting	Tires and Wheels	Other mfr
Other Air Bags	Parking Brakes	Other mfr
Steering	Other Air Bags	Other mfr
Other Air Bags	Tires and Wheels	Other mfr
Power Train	Parking Brakes	Other mfr
Seat Belts, Child Seat Anchors	Parking Brakes	Other mfr
Seats	Parking Brakes	Other mfr
Service Brakes	Parking Brakes	Other mfr
Steering	Parking Brakes	Other mfr
Structure	Parking Brakes	Other mfr
Suspension	Parking Brakes	Other mfr
Takata Air Bags	Parking Brakes	Other mfr
Tires and Wheels	Parking Brakes	Other mfr
Vehicle Speed Control	Parking Brakes	Other mfr
Visibility	Parking Brakes	Other mfr
Power Train	Tires and Wheels	Other mfr
Service Brakes	Seat Belts, Child Seat Anchors	Other mfr
Steering	Seat Belts, Child Seat Anchors	Other mfr
Seats	Tires and Wheels	Other mfr
Service Brakes	Tires and Wheels	Other mfr
Steering	Structure	Other mfr
Suspension	Tires and Wheels	Other mfr
Takata Air Bags	Tires and Wheels	Other mfr
Steering	Tires and Wheels	Other mfr
Visibility	Tires and Wheels	Other mfr
Engine & Cooling	Lighting	Toyota
Fuel System	Lighting	Toyota
Other Air Bags	Lighting	Toyota
Parking Brakes	Lighting	Toyota
Service Brakes	Lighting	Toyota
Steering	Lighting	Toyota
Takata Air Bags	Lighting	Toyota
Vehicle Speed Control	Lighting	Toyota
Parking Brakes	Suspension	Toyota