



ASPIRING DRIVERS WEIGH AUTOMOTIVE REVOLUTION

Driving-Tests.org surveys its users
about their views on electric cars
and self-driving cars.

March - April 2017



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01 EXECUTIVE SUMMARY

In March 2017, as part of its ongoing marketing campaign, Driving-Tests.org (herein called (DTO) had held a series of discussions with journalists from automotive, business, and high-tech media on what they would most like to know from aspiring drivers. We offered to survey visitors to DTO's website to collect and analyze their responses.

In March and April, we surveyed tens of thousands of visitors to DTO's website. Visitors surveyed ranged in age from children under 13 to seniors. We then performed a statistical analysis of the results.

The most significant results from our survey are as follows:

1. Respondents were asked if they would consider purchasing an electric car over a comparably priced gasoline-powered vehicle. By at least two to one, respondents in all age groups stated that they would not. The percentages varied slightly by age group.
2. Respondents were asked if they would be concerned about riding in a fully self-driving car. There were strong opinions in both directions. A plurality of respondents stated that they would be extremely concerned, and a somewhat smaller percentage of respondents stated that they would not be concerned at all.
3. Respondents were asked if they believed that the benefits of self-driving cars would outweigh their risks and costs. The percentage of respondents who stated that the benefits would not outweigh the negatives was larger than the percentage who stated that the benefits would outweigh the negatives. Views on this issue appeared to be related to respondents' personal levels of concern about riding in a fully self-driving car.
4. Respondents were asked which auto manufacturer they believed would sell the most electric vehicles and self-driving vehicles in the future. More respondents chose Tesla than any other auto manufacturer. Tesla was followed by Toyota, Honda, Chevrolet, and Ford in that order. A plurality of teenagers (who comprise over 40 percent of DTO's total visitors) believed that Tesla would sell more electric cars and self-driving cars than other manufacturers, but pluralities of older age groups tended to favor Toyota.
5. Respondents who favored Tesla were more likely to consider purchasing an electric car.
6. Responses to these questions were not independent of each other. Rather, the probability that a respondent would answer in a particular way to one question was related to both his or her age and how he or she would answer the other questions. (Details are provided in the rest of this report.)

02 INTRODUCTION

Driving-Tests.org (herein abbreviated DTO) has tried to find out how its own users—aspiring drivers studying for their knowledge tests—feel about these automotive advances. Are they eagerly looking forward to driving such advanced machines?

94%

of traffic accidents are caused by human choice or human error

The computer revolution is bringing Buck Rogers to your next car. The most advanced models now feature automatic emergency braking (AEB), lane departure warning, “smart” cruise control that automatically maintains an adequate following distance, automatic collision avoidance, and self-parking. Even self-driving cars may be on the road in the not-too-distant future. The US Department of Transportation is [working with](#) auto manufacturers to equip all new cars with AEB by September 1, 2022.

A [study](#) conducted by the National Highway Traffic Safety Administration (NHTSA) in 2005–2007 found that some 94 percent of traffic accidents are caused by human choice or human error. Still, handing control of your vehicle over to a computer raises obvious issues of safety, reliability, cybersecurity, ethics, and legal responsibility.

Electric cars are nonpolluting, and their storage batteries can be charged with electricity from any source of power. However, is their range adequate for Americans’ needs? And will enough charging stations be built? Driving-Tests.org (herein abbreviated DTO) has tried to find out how its users—aspiring drivers studying for their knowledge tests—feel about these automotive advances. Are they eagerly looking forward to driving such advanced machines?

03 BACKGROUND

In March 2017, as part of its ongoing marketing campaign, DTO had held a series of discussions with journalists from automotive, business, and high-tech media on what they would most like to know from aspiring drivers. We offered to survey visitors to DTO's website to collect and analyze their responses. Fred Lambert, the Editor-in-Chief of [Elektrek](#), suggested asking them the following three questions:

1. Would you choose an electric vehicle over a comparably priced gas-powered vehicle?
{Yes, No}
2. Which brand (make) of car do you think is most innovative today? {Respondents could name any brand they wished.}
3. For you to trust riding in a self-driving car, it has to be {just as, twice as, four times as, ten times as} reliable as a human driver.

We performed a couple of preliminary experimental surveys on the [Survicate](#) platform. Around this time, DTO hired a professional statistician, Iuliana David, to assist us with the statistical analyses of the survey results. After discussing these questions and preliminary survey results with her, we concluded that Questions 2 and 3 would need significant reformulation to yield useful and statistically significant survey results.

Problems with surveying visitors to DTO about Question 2 included the following:

- **Poor response:** The overwhelming majority of respondents were unable to conceive of responses to this open-ended question. As a result, our sample sizes for this question were much smaller than we had hoped.
- **Models instead of makes:** For example, one respondent entered "Camaro" instead of "Chevrolet."
- **Misunderstandings:** One respondent entered "NAPA" [Auto Parts].
- **Numerous snarky or "troll" responses**

We decided to reformulate this question as multiple choice. In our early sample runs, Chevrolet, Ford, Honda, Tesla, and Toyota had been the clear front-runners, so we decided to limit this question to those five choices plus a catchall “Other or None” category.

We had also noticed that respondents had not rated Tesla better than fourth place, despite their well-publicized advances in electric propulsion and self-driving technology. We wondered if respondents had favored other makes of cars as more innovative than Tesla because they were judging “innovation” differently. Automakers have, of course, introduced technological innovations (such as Android Auto) recently that drivers may welcome but which have nothing to do with electric propulsion or self-driving. Accordingly, we decided to refocus the question from the vague notion of “innovation” toward a more objective assessment of the auto manufacturers’ relative commercial success in selling electric or self-driving cars.

Question 3 had originally been formulated as multiple choice. However, we became increasingly concerned about the subjectivity and ambiguity of the provided choices. Just how did respondents think about reliability? By “twice as reliable,” did they mean half as many repairs or half as many accidents? Moreover, how did they measure reliability, since we did not provide an objective standard for them to use?

As with question 2, we decided that this question needed some reformulation to make it more objective and less ambiguous.

SURVEY QUESTIONS

For our main (and largest) survey, we decided on the following four questions for DTO’s visitors:

1. Would you choose an electric vehicle over a comparably priced gas-powered vehicle? {Yes, No}
2. How concerned would you be about riding in a fully self-driving car? {Scale from 0 to 10}
3. Will the benefits of self-driving vehicles outweigh their risks and costs? {Scale from 0 to 10}
4. Which of the following manufacturers do you think will sell the most electric vehicles and self-driving vehicles in the next 10 years? {Ford, Chevrolet, Honda, Tesla, Toyota, Other or None}

04 APPROACH

6-12
13-19
20-35
36-50
51-64

We knew that DTO's users were overwhelmingly young, so we thought it would be worthwhile to contrast the views of Millennials who visited DTO with the views of non-Millennial visitors.

There is no standard definition of "Millennial." According to [this article](#), the term may have originated with Neil Howe and William Strauss, authors of the 1991 book *Generations: The History of America's Future, 1584 to 2069*. Howe and Strauss define the Millennial cohort as consisting of individuals born between 1982 and 2004. We decided to adopt this definition.

Accordingly, our survey asked each respondent to state to which of the following age groups he or she belonged: **6-12**, **13-19**, **20-35**, **36-50**, **51-64**, and **65-90**. Millennials, as defined by Howe and Strauss, comprise the second and third categories.

It should be noted that at least one of us on this project owns a Tesla electric car and even invests in Tesla. However, we were aware of the need to avoid bias or conflict of interest. We were careful not to introduce any pro-Tesla (or anti-Tesla) bias into either the questions to the users or the design of the survey.

4.1 CHOICE OF SURVICATE PLATFORM

For performing the surveys, we had originally chosen the Google Surveys platform because the range and breadth of its tools had appeared adequate for the kinds of surveys we were planning to do, and we were already familiar with those tools. We started running surveys on March 10, 2017, but we soon found that gathering responses on Google Surveys was unacceptably slow. The Google Surveys Team admitted that currently, website surveys were limited to non-mobile devices for which all ad blockers were disabled. That would certainly limit our universe of potential respondents since most DTO users are (as we soon confirmed) young, and many young people now use smartphones or tablets instead of computers. (DTO even makes available smartphone apps for users who wish to take DTO's practice driving tests on mobile devices.)

We decided to switch from Google Surveys to Survicate. Like Google Surveys, Survicate offers a set of tools and survey templates that allow you to set up and run a website survey. Survicate allows you to export both the raw data and the summary statistics to Microsoft Excel-compatible spreadsheets.

We were unfamiliar with Survicate's toolset, so there was a learning curve associated with it at first. Also, Survicate's tools did not feel quite as professional as those provided by Google Surveys. It took several hours plus some live chats with Survicate's support staff for us to redesign and set up our first experimental survey on Survicate, after which we were up and running on March 24, 2017.

Almost at once, we noticed that responses were coming in much faster than they had ever done on Google Surveys. This was probably because Survicate, unlike Google Surveys, fully supports conducting surveys on mobile devices as well as on computers.

Now with Survicate, we decided to perform our largest survey run to date. In the following sections, we will summarize our results.

4.2 CLEANING THE DATASETS

The raw dataset contained many standard Survicate survey fields that we did not need or want, such as the respondent's full name (which we had not asked respondents to provide). We scrubbed or ignored these fields.

A more serious problem in the raw dataset was the existence of dozens of erroneous records. We had carefully specified the choice of age group and questions 1 through 4 as multiple choice with mutually exclusive choices. Nevertheless, 510 records (out of some 157,000 records gathered) contained multiple responses such as multiple age groups (e.g., "6-12, 13-19") or car brands (e.g., "Honda, Toyota"). All these records had to be eliminated from our analysis. Survicate is aware of the problem, but they have not yet supplied a fix.

4.3 TOOLSET

For the statistical analysis of the datasets, Ms. David, our statistician, preferred to use the R language and toolset. [R](#) is an open-source environment for statistical analysis and graphing. It is capable of handling very large datasets, even datasets much larger than our own.

05 SURVEY RESULTS

Our main survey was also our largest, at **158,000 visitor responses** garnered from April 4 to April 17, 2017.

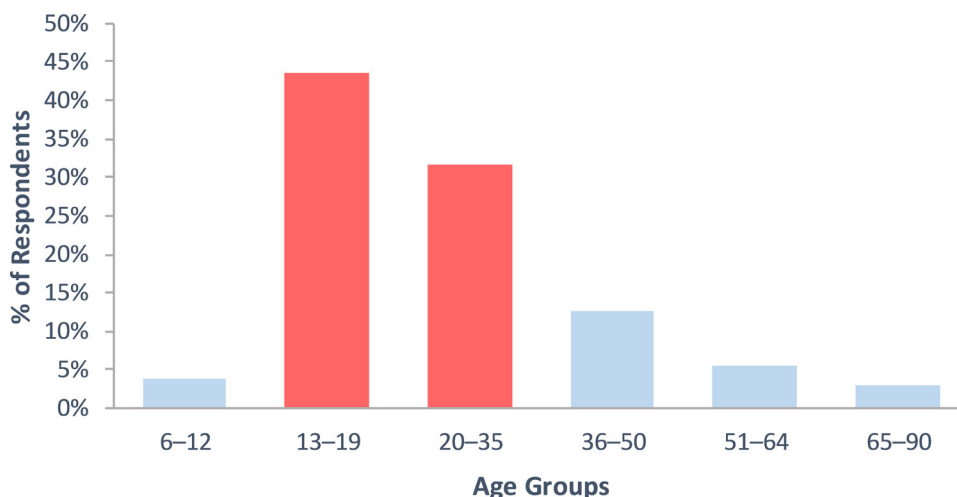
158,000 *visitor responses*

5.1 AGE DISTRIBUTION

As stated earlier, our survey covered six age groups: 6–12, 13–19, 20–35, 36–50, 51–64, and 65–90. The results of our tally by age group were as follows.

Millennials strongly predominated, representing 75.1% of respondents. In fact, 43.5% of respondents were teenagers. (The margin of error was 0.3%.) The average age (weighted by respondents per age group) was 26.9, within the Millennial age range as we had expected.

Millennials Predominate



DTO caters to several types of users of differing ages, including the following:

- Aspiring automobile drivers (mostly teenagers)
- Aspiring motorcyclists seeking a motorcycle endorsement on their existing driver's licenses
- Aspiring commercial drivers (who must be at least 18 years of age to obtain a commercial learner's permit)
- Seniors looking to brush up on their driving skills

We wondered if this variety might cause the DTO user distribution by age to deviate from a normal distribution. We decided to test the null hypothesis that the percentages of respondents by age group form a normal distribution. However, there was a problem.

The tests for normality usually require the bins of a histogram to have equal widths. The age ranges of our age groups are not equally wide. That is, the 65–90 age group includes about four times as many years as the 6–12 age group, meaning that the 65–90 bin of the histogram would be four times as wide as the 6–12 bin.

To correct this bias so we could have bars of equal widths, we weighted the number of respondents per age group to normalize the relative widths (age ranges) of each age group while keeping the total number of respondents the same.

Next, we ran a [Jarque-Bera test](#) for normality on the numbers of respondents in each weighted age group. The computed P-value was 0.5184, meaning that we could not reject the null hypothesis.

5.2 RESPONSE DROP-OFF

For our main (and largest) survey run with four questions, the drop-off rates are shown in the following “heat map” chart. The more saturated the color, the larger the percentage drop-off:

	Largest % Drop-Offs Occurred Earlier				
	Respondents	Question 1 %	Question 2 %	Question 3 %	Question 4 %
Age	157749	-12.6%	-24.4%	-31.3%	-36.3%
Question 1	137797		-13.4%	-21.4%	-27.1%
Question 2	119311			-9.2%	-15.8%
Question 3	108299				-7.2%
Question 4	100467				

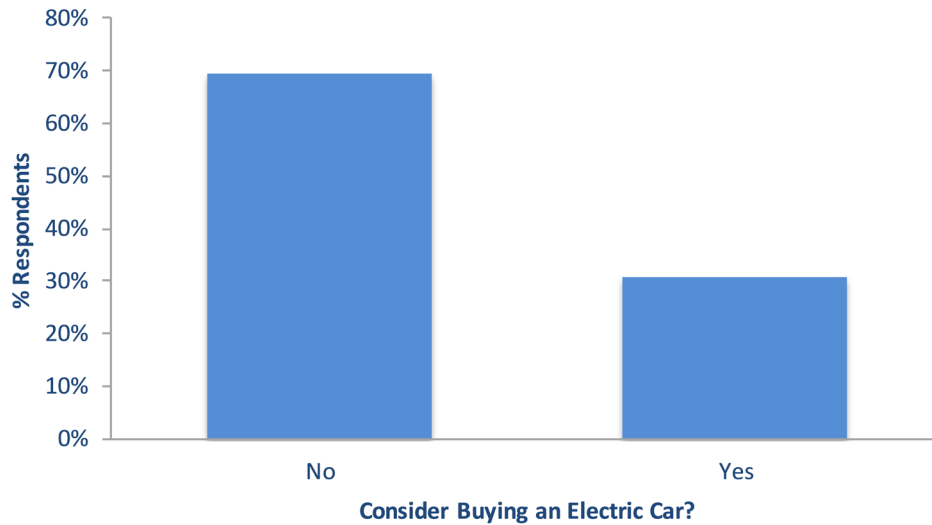
The largest drop-offs tended to occur earlier in the survey. That is, the largest drop-offs occurred after asking the respondent for his or her age or asking the respondent for his or her response to question 1.

5.3 QUESTION 1

Of the four survey questions, the most striking results of the three survey questions were those from Question 1: “Would you consider purchasing an electric vehicle over a comparably priced gas-powered vehicle?” Visitors to DTO who responded to our survey overwhelmingly said no.

Respondents in all age groups rejected electric vehicles by about a two-to-one margin. Across all age groups, the result was 30.6% Yes, 69.4% No with a margin of error of only +/- 0.1% (because of the very large sample size). The following chart illustrates this result.

Respondents Said "NO!" to Electric Cars



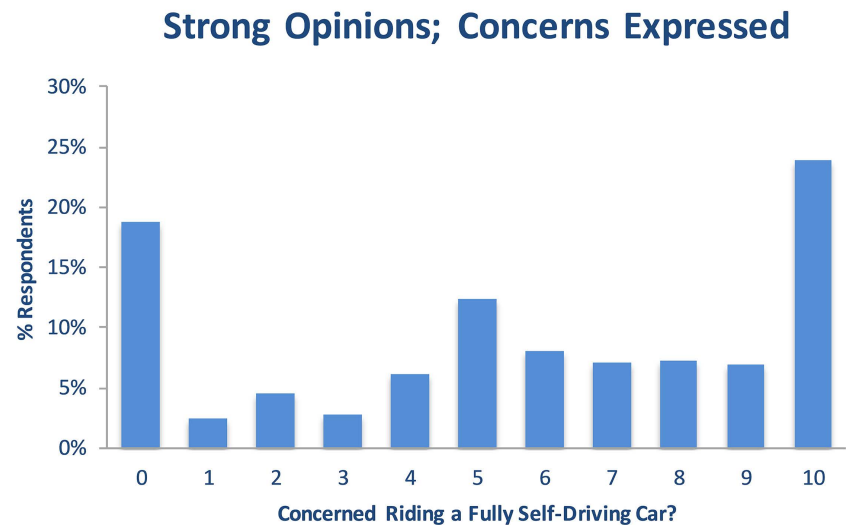
5.4 QUESTION 2

Question 2 to our respondents was "On a scale from 0 to 10, how concerned would you be about riding in a self-driving car? (0 = not at all concerned; 10 = extremely concerned)"

The percentage responses were as follows:

Response	% Respondents
0	18.8%
1	2.4%
2	4.6%
3	2.7%
4	6.1%
5	12.3%
6	8.0%
7	7.1%
8	7.2%
9	6.9%
10	23.9%

Though the mean score was 5.62, about in the center of the 0–10 range, the standard deviation was wide: 3.66. These results are illustrated in the following chart.



This chart illustrates how controversial this question was for our respondents. A slim majority (52.0%) of our respondents had strong opinions one way or the other (responses 0, 1, 9, and 10). However, the proportion (30.8%) who responded that they would be very or extremely concerned about riding in a self-driving car (responses 9 and 10) was greater than the percentage (21.2%) who responded that they would have few or no concerns (responses 0 and 1). (The margin of error here is +/- 0.2 percentage points.)

5.5 QUESTION 3

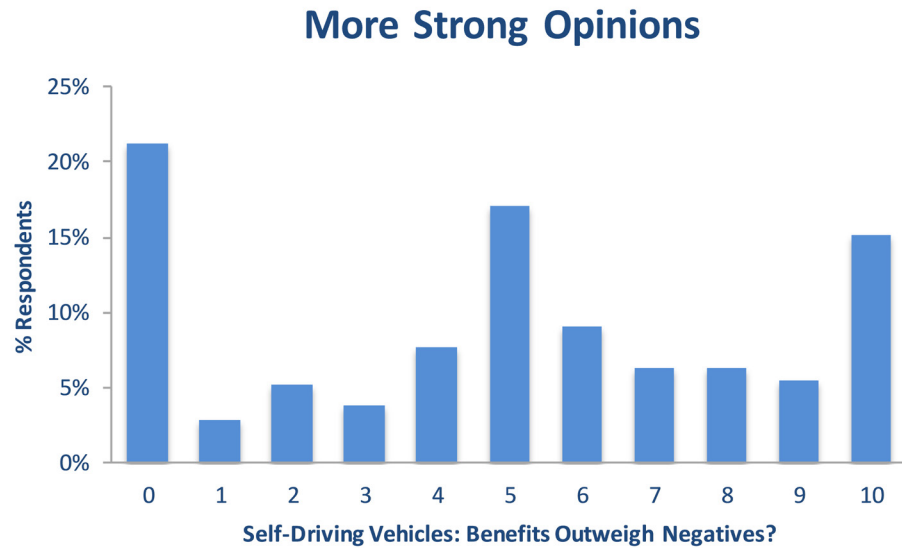
Question 3 to our respondents was “On a scale from 0 to 10, will the benefits of self-driving vehicles outweigh their risks and costs? (0 = impossible; 10 = definitely)”

The percentage responses were as follows:

Response	% Respondents
0	21.2%
1	2.8%
2	5.2%
3	3.8%
4	7.8%
5	17.1%
6	9.1%
7	6.3%
8	6.3%
9	5.4%
10	15.1%

Though the mean score was 4.90, about in the center of the range 0–10, the standard deviation was wide: 3.46.

These results are illustrated in the following chart.



This chart illustrates that this question was nearly as controversial for our respondents as question 2. Nearly half (44.5%) of the responses to this question reflected strong opinions (responses 0, 1, 9, and 10), although for this question, quite a few respondents didn't know or were unsure (response 5). More respondents (24.0%) believed that the benefits of self-driving cars would likely or definitely not outweigh the costs and risks (responses 0 and 1) than those (20.5%) who believed the benefits were worth it (responses 9 and 10). (The margin of error is +/- 0.2 percentage points.)

Combined with the concerns about riding in a self-driving car expressed by respondents in question 2, this suggests that respondents are cautious about taking advantage of this new technology.

5.6 QUESTION 4

Question 4 to our respondents was "Which of the following manufacturers do you think will sell the most electric vehicles and self-driving vehicles in the next 10 years?"

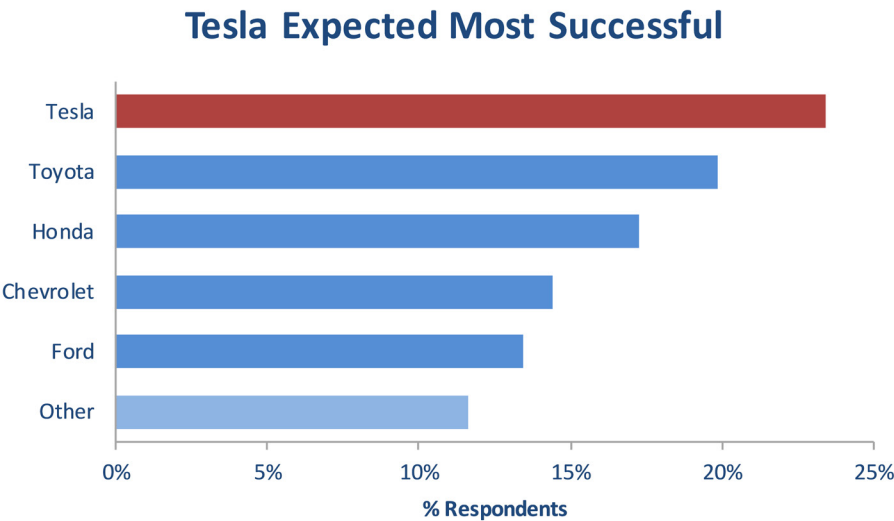
We had reformulated this question as multiple choice, with the choices Chevrolet, Ford,

Honda, Tesla, Toyota, and Other or None.

Many of the respondents had evidently heard about Tesla’s well-publicized advances in electric self-driving cars. The percentage responses were as follows:

Response	% Respondents
Chevrolet	14.4%
Ford	13.4%
Honda	17.2%
Tesla	23.4%
Toyota	19.9%
Other or None	11.6%

These responses are illustrated in the following chart.



Among these respondents, Tesla led its closest rival, Toyota, by 3.5 percentage points.

The percentage differences between these brands were not great. The difference between the most favored brand, Tesla, and the least-favored brand, Ford, was 10 percentage points. However, the margin of error for our large sample (100,106 respondents) was only 0.1 percentage points, so even differences among brands of a few percentage points may be judged significant.

5.7 CROSSTABS

In this section, we will look at the extent to which responses to these various questions might have been related. For example, was a respondent's belief that Tesla will do well commercially related to whether he or she would personally consider purchasing an electric car?

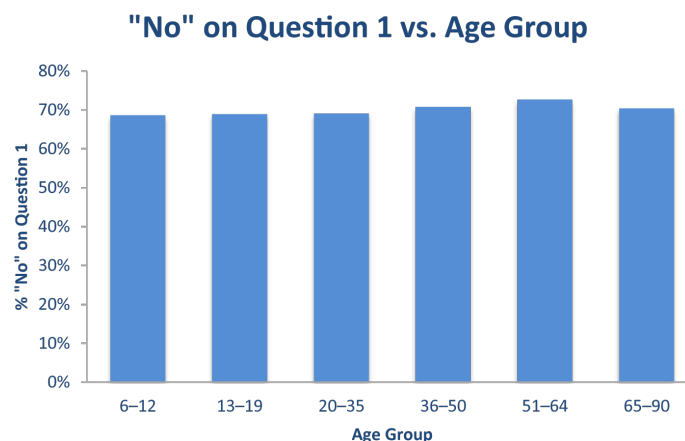
The first step in analyzing crosstabs was to do pairwise chi-square testing between certain pairs of variables. Our main interest was in question 1 as a dependent variable, so that drove our choices of chi-square tests.

Finally, we ran a logistic regression with question 1 as the dependent variable, and age group and the other three questions as independent variables. This would let us see how much of the variation in the respondents' answers to question 1 could be predicted from their age groups and their responses to the other three questions.

5.7.1 QUESTION 1 VS. AGE GROUP

Did responses to Question 1 (whether respondents would consider purchasing an electric car) vary by age?

As stated earlier, the overall response to question 1 was overwhelmingly negative by about two to one. When broken down by age group, each age group also rejected electric cars by a comparable margin. In the three older age groups, the percentage was slightly over 70%; in the three younger age groups (including Millennials), the percentage was slightly smaller, about 69%. This is still a significant result because the margin of error is a fraction of one percentage point. These results are illustrated in the following chart.



To test these results, we formulated the null hypothesis that the response to question 1 does not differ by age group, and ran a chi-square test on these two variables. The resulting P-value was extremely small (3.2×10^{-12}), so we can reject the null hypothesis and conclude that relative to the small margin of error, there is a difference in responses by age group, albeit a small one.

5.7.2 QUESTION 4 VS. AGE GROUP

As stated in section 5.6, more respondents believed that Tesla would sell more electric cars and self-driving cars than Chevrolet, Ford, Honda, or Toyota. However, was this belief uniform across all age groups?

A breakdown of responses to question 4 by age group shows that it was not.

	Toyota	Honda	Ford	Chevrolet	Tesla
6–12	11.9%	14.7%	17.1%	15.5%	11.0%
13–19	14.5%	16.3%	17.6%	16.8%	18.4%
20–35	21.9%	16.5%	15.8%	16.5%	14.2%
36–50	20.2%	14.3%	15.6%	16.2%	14.3%
51–64	15.5%	11.1%	14.5%	11.8%	13.5%
65–90	18.1%	18.3%	15.8%	17.2%	16.2%

This “heat map” chart shows the percentage of each age group that favored each brand. Each row is colored in a particular color; the more saturated the color, the higher the percentage.

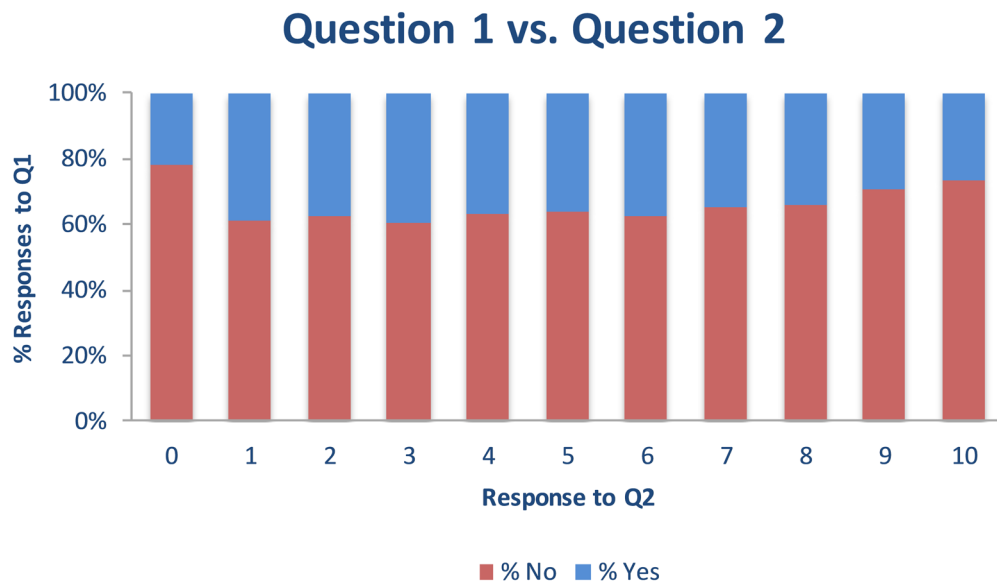
As can be seen from the chart, high expectations for Tesla were limited to the large teenage cohort (an estimated 43.5%) of DTO's visitors, which is why Tesla led among all respondents in total. Older age groups tended to favor Toyota (which is why Toyota was in second place).

We decided to test the null hypothesis that the choice of car brand was independent of age group. We ran a chi-square test on these two variables. The computed P-value was extremely small (2.2×10^{-16}), so we could reject the null hypothesis.

5.7.3 QUESTION 1 VS. QUESTION 2

Was there a relationship between respondents' attitudes toward electric cars and their levels of concern about riding in a fully self-driving car?

The following chart relates the relative proportions of "Yes" and "No" responses to question 1 as a function of the corresponding responses to Question 2.



This chart shows that the relative proportions of "Yes" and "No" responses to question 1 tended to vary with the response to Question 2. Among all respondents who answered both Question 1 and Question 2, 31.0% answered "Yes" to Question 1 and 69.0% answered "No." However, among those who answered 0 to Question 3 (i.e., they were not at all concerned about riding in a self-driving car), 22.2% answered "Yes" to Question 1 and 77.8% answered "No."

To test this, we formulated the null hypothesis that the response to Question 1 was independent of the response to Question 2. The chi-square test yielded a P-value of less than 2.2×10^{-16} , so we can safely reject this null hypothesis and conclude that the response to Question 1 is related to the response to Question 2.

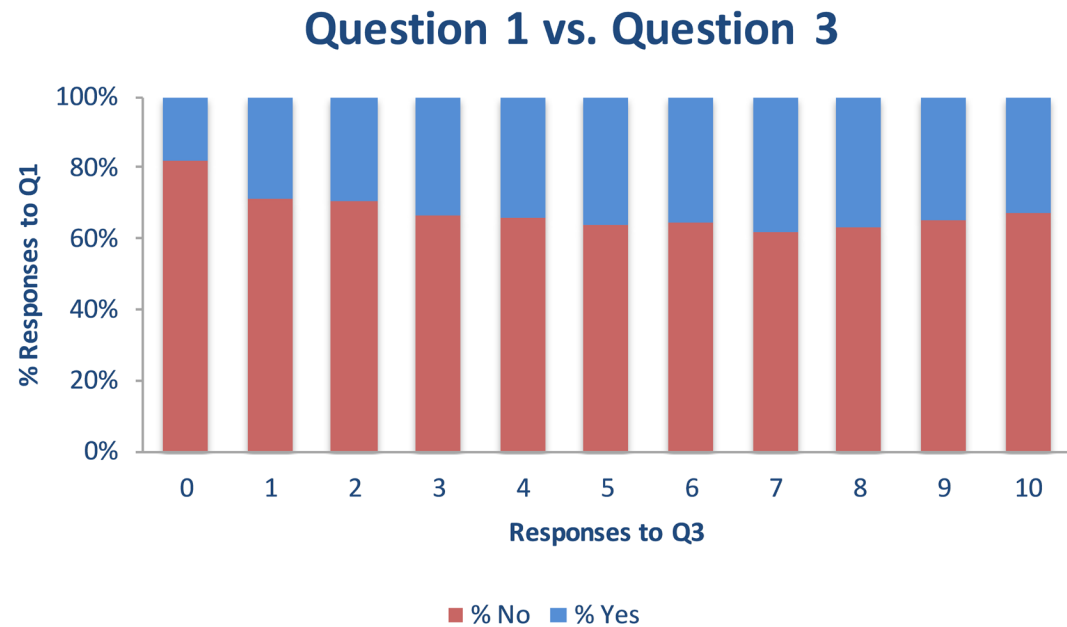
As the chart illustrates, however, there is not a consistent upward or downward trend. From response 0 through response 3, the percentage of "No" responses to Question 1 declines;

from response 6 through response 10, it rises again. This may be due to the unusual nature of the distribution of responses to Question 2, as we saw in section 5.4. We will briefly revisit this issue in section 5.7.6.

5.7.4 QUESTION 1 VS. QUESTION 3

Was there a relationship between respondents’ attitudes toward electric cars and their views on whether the benefits of self-driving cars would outweigh their risks and costs?

The following chart relates the relative proportions of “Yes” and “No” responses to question 1 as a function of the corresponding responses to Question 3.



This chart shows that the relative proportions of “Yes” and “No” responses to question 1 tended to vary with the response to Question 3. Among all respondents who answered both Question 1 and Question 3, 31.0% answered “Yes” to Question 1 and 69.0% answered “No.” However, among those who answered 0 to Question 3 (i.e., they were sure that the benefits of self-driving cars would not outweigh their negatives), 18.1% answered “Yes” and 81.9% answered “No.”

To test this, we formulated the null hypothesis that the response to Question 1 was independent of the response to Question 3. The chi-square test yielded a P-value of less than 2.2×10^{-16} , so we can safely reject this null hypothesis and conclude that the response to Question 1 is related to the response to Question 3.

As the chart illustrates, however, there is not a consistent upward or downward trend. From response 0 through response 5, the percentage of “No” responses to Question 1 declines; from response 7 through response 10, it rises again. This may be due to the unusual nature of the distribution of responses to Question 3, as we saw in section 5.5.

5.7.5 QUESTION 3 VS. QUESTION 2

Was there a relationship between respondents’ views of the relative benefits of self-driving cars and their personal levels of concern about riding in one?

The following “heat map” chart shows that responses to Question 2 (“How concerned would you be about riding in a fully self-driving car?”) were not independent of responses to Question 3 (“Will the benefits of self-driving cars outweigh their risks and costs?”). In this chart, responses 0, 1, 2, 3, and 4 were grouped together, as were responses 6, 7, 8, 9, and 10.

		Question 2		
		0–4	5	6–10
	0–4	23.4%	2.1%	15.2%
Question 3	5	3.0%	7.2%	7.0%
	6–10	8.3%	3.0%	30.9%

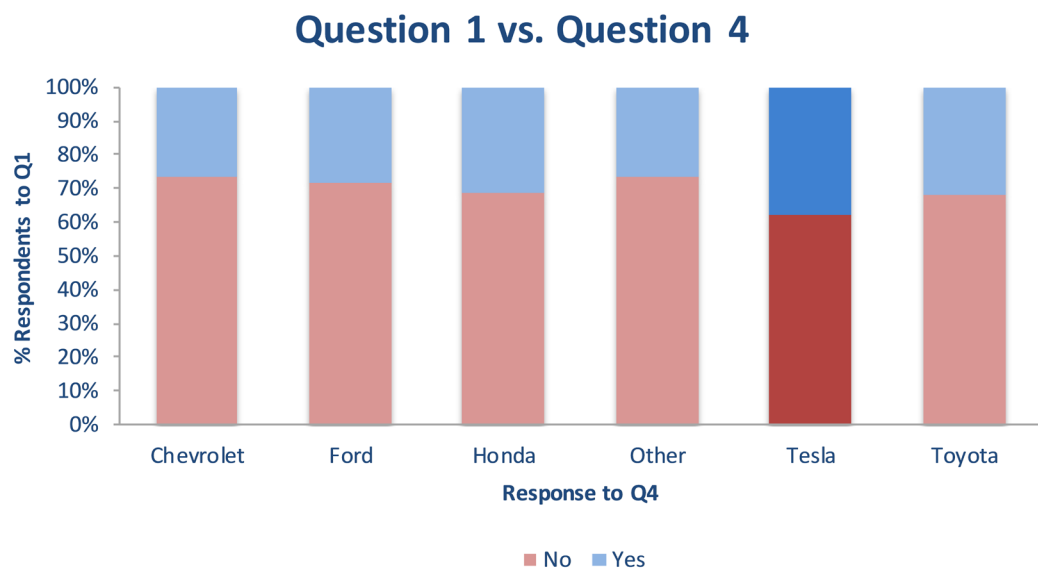
To test this observation, we formulated the null hypothesis that the proportions of responses to Question 3 were independent of the proportions of responses to Question 2. A chi-square test yielded a P-value of 0.0002, so we can safely reject the null hypothesis and conclude that the proportions of responses to Question 3 are not independent of the proportions of responses to Question 2.

Interestingly, 30.9% of respondents believed that the benefits of self-driving cars would outweigh their risks and costs, even though they personally would be concerned about riding in one.

5.7.6 QUESTION 1 VS. QUESTION 4

Was there a relationship between respondents' attitudes toward electric cars and their choices of car brand as most likely to be the leading manufacturer of such cars?

The following chart relates the relative proportions of "Yes" and "No" responses to question 1 as a function of the corresponding responses (car brands) to question 4.



This chart shows that the relative proportions of "Yes" and "No" responses to question 1 tended to vary with the choice of car brand in Question 4. Among all respondents who answered both Question 1 and Question 4, 31.3% responded "Yes" to Question 1 and 68.7% responded "No." However, among respondents who chose Tesla in Question 4, for example, 37.6% responded "Yes" to Question 1 and 62.4% responded "No." The percentage of those who answered "Yes" to Question 1 was higher for Tesla than for any of the other four brand choices.

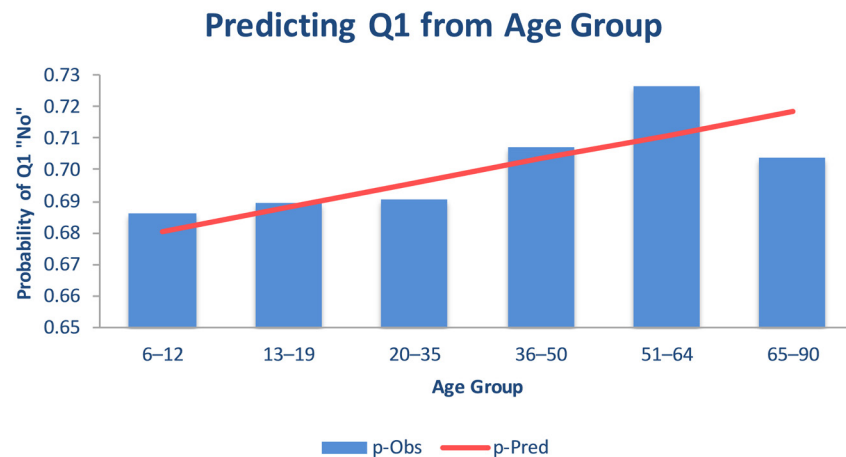
To test this, we formulated the null hypothesis that the response to Question 1 was independent of the response to Question 4. The chi-square test yielded a P-value of less than 2.2×10^{-16} , so we can safely reject this null hypothesis and conclude that the response to Question 1 is related to the response to Question 4.

5.7.7 PREDICTING QUESTION 1 RESPONSES

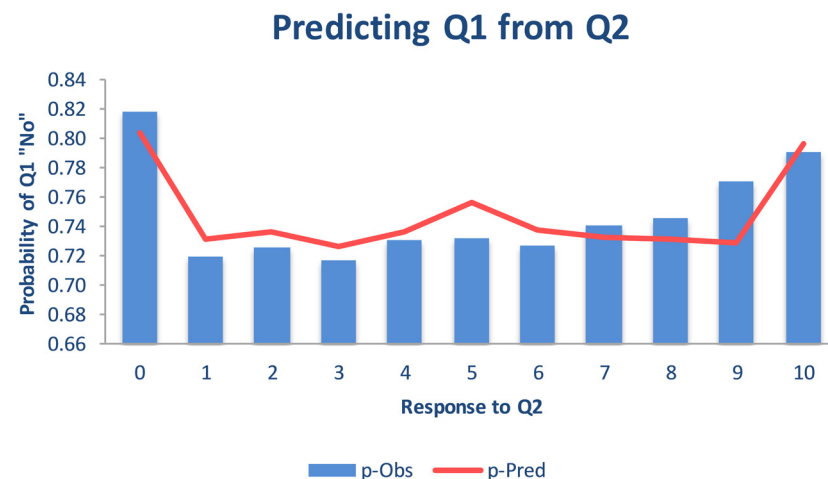
As a final step in crosstabs analysis, we ran a logistic regression with question 1 as the dependent variable, and age group and the other three questions as the four independent variables. We employed logistic regression because the possible responses to question 1 are just two discrete values (Yes or No).

We found the following results:

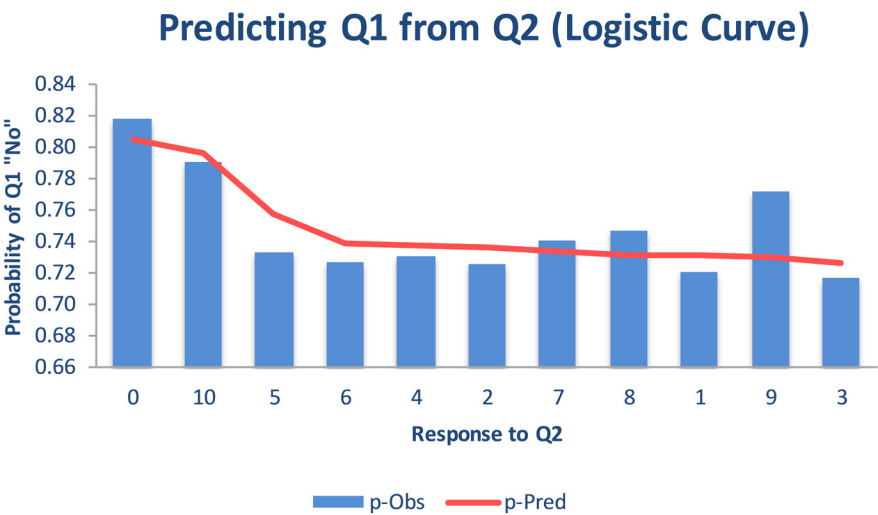
69.4% of the variation in the responses to question 1 (considering purchasing an electric car) could be accounted for by the respondents' age groups.



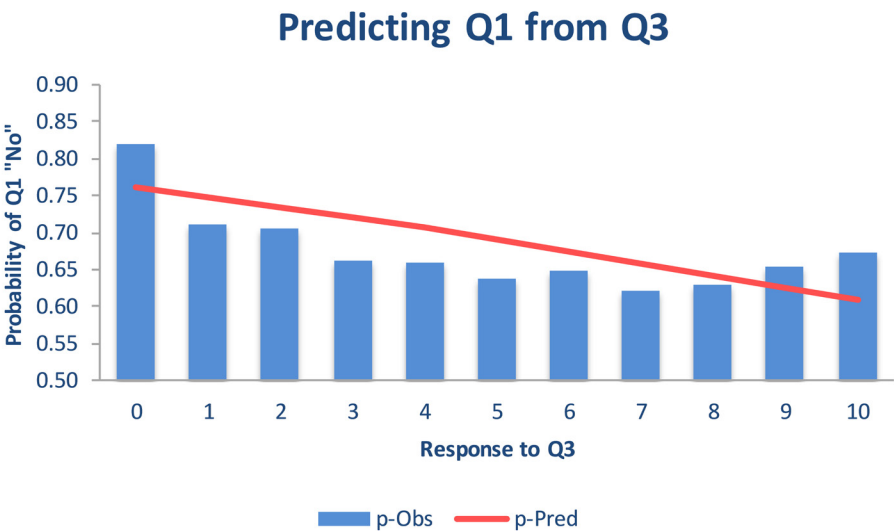
76.4% of the variation in the responses to question 1 could be accounted for by the responses to question 2 (level of concern about riding in a fully self-driving car).



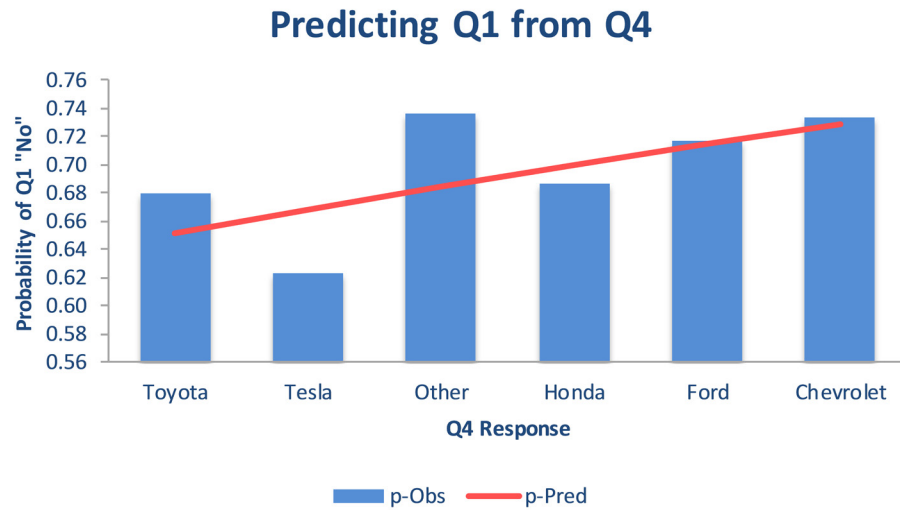
Note, however, that the unusual distribution of responses makes the shape of the logistic regression curve (whose equation approximates that distribution) difficult to see. We can see it more clearly if we reorder the possible responses to Question 2 so the logistic curve declines monotonically:



In this chart, the characteristic “S” shape of the logistic curve is evident. 69.0% of the variation in the responses to question 1 could be accounted for by the responses to Question 3 (whether the benefits of self-driving vehicles would outweigh their negatives).



68.7% of the variation in the responses to question 1 could be accounted for by the responses to question 4.



Hence, age group and responses to Questions 2, 3, and 4 were all predictors of responses to Question 1.

06 FUTURE DIRECTIONS

Our analysis indicates that even Millennials, let alone older users of DTO, are wary of the new electric and self-driving cars. In the future, we may investigate this further. What are the specific concerns that these aspiring drivers have? Are they like the concerns of more experienced drivers?

We may also investigate how these concerns could be mitigated. Would users of DTO feel more comfortable driving a hybrid electric vehicle like the Chevrolet Volt, which alleviates “range anxiety” through its backup internal combustion engine? Or are there psychological or sociological barriers to electric vehicles? If so, how could they be overcome? Would users of DTO feel more comfortable adopting semi-autonomous technologies short of self-driving, such as adaptive cruise control and automatic collision avoidance? Or do they worry that all this new technology is unproven or risky? Or do they just resent the loss of autonomy and control of the vehicle that all such electronic support of the driver entails? In a future survey, we may pose some follow-up questions to investigate this.

Finally, how does public support for electric cars or self-driving cars in America compare with that in other countries? We plan to do survey runs at DTO’s sister sites to gather and analyze responses to the same four survey questions:

- Aussie-driver.com (Australia)
- Find-a-driving-school.ca (Canada)
- G1.ca (Ontario)
- Toptests.co.uk (United Kingdom)

07 CONCLUSIONS

The most significant results from our survey are as follows:

- 1. Question 1:** An overwhelming percentage of respondents in all age groups stated that they would not consider purchasing an electric car over a comparably priced gasoline-powered vehicle. The percentage of those who responded “No” to Question 1 varied slightly by age group.
- 2. Question 2:** On the level of concern about riding in a fully self-driving car, there were strong opinions in both directions. A plurality of respondents stated that they would be extremely concerned, and a somewhat smaller percentage of respondents stated that they would not be concerned at all.
- 3. Question 3:** As with question 2, there was strong disagreement on the question of whether the benefits of self-driving cars would outweigh their risks and costs. The percentage of respondents who stated that the benefits would not outweigh the negatives was larger than the percentage who stated that the benefits would outweigh the negatives. Responses to Question 3 appear to be related to responses to question 2.
- 4. Question 4:** On the question of which auto manufacturer would sell the most electric and self-driving vehicles in the future, more respondents chose Tesla than any other auto manufacturer. Tesla was followed by Toyota, Honda, Chevrolet, and Ford in that order. A plurality of teenagers (who comprise an estimated 43.5 percent of DTO’s total visitors) believed that Tesla would sell more electric and self-driving cars than other manufacturers, but pluralities of older age groups tended to favor Toyota.
- 5. Respondents who favored Tesla in Question 4** were more likely to favor electric cars in Question 1.
- 6. For responses to Question 1,** age group and responses to Question 2, Question 3, and Question 4 were all predictors.

There also seems to be a significant common attitude underlying the responses to the questions: Caution. Evidently, most visitors to DTO are not prepared, let alone eager, to embrace electric cars and self-driving cars.

A [poll](#) taken in August 2016 revealed that some 50 percent of Millennial Americans would consider buying an electric car—a significantly larger proportion than we found in our own surveys. (That poll had a margin of error of +/- 3 percentage points.)

What might account for the difference? We can speculate that it is due to the type of Millennial visitors that DTO typically gets: student drivers. DTO is designed to help train student drivers. Student drivers are urged by their instructors to do everything cautiously and “by the book” to pass their written exams and road tests. Moreover, such semi-autonomous features as self-parking are of no help to the student driver, since their use is typically disallowed on standard driving road tests. Thus, the student driver’s mindset may not be conducive to experimentation with state-of-the-art or unproven automotive technology.

08 APPENDIX

Here is a very brief summary of the main statistics techniques we used.

8.1 MARGIN OF ERROR

The *margin of error* is usually defined as the amount by which a population statistic may differ from the sample statistic for a given probability. In typical surveys and public opinion polls, there is a 95% probability that the sample statistic (usually a proportion or percentage) differs from the corresponding population statistic by no more than the margin of error. We chose that same level of confidence for our survey results.

To compute the margin of error for a percentage p in a sample of size N , we first compute the standard error for the sampling distribution of proportions:

$$\sigma = \sqrt{\frac{p(1-p)}{N}}$$

This statistic behaves like the standard deviation of a normal distribution. That is, the population proportion will fall within the standard error of the sample proportion about 68.26% of the time, and within two standard errors about 95.45% of the time.

Therefore, for 95% confidence in our sample statistic, we compute the margin of error as equal to twice the standard error.

8.2 THE CHI-SQUARE TEST

Suppose that in a sample, there are k possible events E_i , each of which is observed to occur with the observed frequency o_i . According to the null hypothesis, we expect each to occur with the expected frequency e_i . Then to decide if the observed frequencies differ sufficient-

ly from the expected frequencies so as to cause us to reject the null hypothesis, we compute the *chi-square statistic*

$$\chi^2 = \sum_{j=1}^k \frac{(o_j - e_j)^2}{e_j}$$

The sampling distribution of this statistic is approximated by the chi-square distribution.

8.3 LOGISTIC REGRESSION

Logistic regression is a type of regression in which the dependent variable is categorical rather than mathematically continuous. That is, the dependent variable can only take on one of several discrete values. Hence, it does not make sense for regression to attempt to predict the values of the dependent variable, since these are already defined. Instead, logistic regression computes the probability that the dependent variable will equal one of those values.

In our case, the dependent variable was the respondents' answers to question 1, which could only be "Yes" or "No."

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