

Online Appendix

The Welfare Effects of Misperceived Product Costs: Data and Calibrations from the Automobile Market

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July 22, 2012

1 Online Appendices

1.1 Online Appendix I: Details of Survey Questions

At the outset of the survey, respondents were told that "The next questions are about the vehicles you own and the time when you bought them. We know that some of the questions may be hard to answer. If you don't know the exact answer, just give your best guess. If you ever want to go back and change a previous answer, just click on the "Back" buttons." The body of the survey then had four parts, each with several questions.

1.1.1 Part 1

In Part 1, respondents were asked about their current vehicle:

Q1.1: What is the make, model, and model year of the vehicle that you personally usually drive?

Q1.2: When did you buy your vehicle?

Q1.3: If you bought your vehicle from a dealership, what price did you pay?

For Q1.1, the vehicles were selected from a drop-down menu that included all vehicles with official Environmental Protection Agency fuel economy ratings between model years 1984 and 2011. In order to precisely match the respondent's current vehicle to its fuel economy rating, respondents were asked to report the transmission type (automatic or manual), drive type (e.g. two-wheel drive vs. all-wheel drive), and engine size in cylinders and liters. The response to Q1.1 is denoted below as [current vehicle], while the response to Q1.2 is denoted as [purchase year].

1.1.2 Part 2

In Part 2, respondents were asked about fuel costs for their current vehicle. Respondents were randomized into one of two frames, "Flow" and "Total." In the former frame, respondents were asked to report the flow of gasoline costs for their vehicle. They were allowed to answer per week, per month, or per year. In the "Total" frame, respondents were asked to report the total anticipated fuel costs over the remainder of the time that they would own it. The questions were:

Q2.1: What type of fuel do you usually put in your vehicle?

The answer to this question is denoted below as [fuel]. The options were regular, midgrade, and premium gasoline, diesel, E85 (ethanol), liquified propane gas, and compressed natural gas.

"Flow" Group

Q2.2F: What is the current price of [fuel] per gallon?

Q2.3F: At the current [fuel] price, how much money is spent to buy [fuel] for your vehicle?

"Total" Group

Q2.2T: Think about your vehicle, the [current vehicle]. Eventually you will replace it or stop using it: you might trade it in at a dealership, sell it to someone else and buy a new one, or just stop driving it. If you had to make your best guess, how long from now do you think that will be?

The answer to this question is denoted below as [future ownership period].

Q2.3T: Over the [future ownership period], what do you think will be the average price of [fuel] per gallon?

Q2.4T: How much money do you think will be spent to buy [fuel] for your vehicle over the [future ownership period]?

The responses to Part 2 are used to construct the annualized gas cost and vehicle-miles traveled for the current vehicle, denoted G_{io}^* and m_i , respectively. For the Total Group, responses are in real dollars.¹

1.1.3 Part 3

In Part 3, respondents were asked about the counterfactual fuel costs if they had instead bought their second choice vehicle. The Flow and Total frames were maintained, and respondents in each frame were additionally randomized into either the "Absolute" or "Relative" frame. In the "Relative" frame, respondents were asked to report the savings or additional costs for fuel for their second choice vehicle relative to their current vehicle. In the "Absolute" frame, they were simply asked about the level of fuel costs for their second choice vehicle. The questions were:

Q3.1: Think back to the time in [year] when you decided to get the [current vehicle]. Most people are deciding between several different vehicles that they like. Imagine that the [current vehicle] did not exist. What would be your "second choice vehicle," the vehicle you probably would have gotten instead?

As in Q1.1, respondents reported make, model, model year, transmission type, drive type, and engine size, so that the second choice vehicle's MPG can be precisely determined. This was also used to determine the fuel type of the second choice vehicle (e.g. premium, regular, diesel, etc.), which is denoted [second fuel] below.

¹It was anticipated that respondents would naturally think about future amounts in real dollars. To reinforce this, respondents in the "Total" group were told at the beginning of the survey: "Some questions will ask you to think about payments you'll make in the future. For these questions, assume that although the prices of particular goods might change, there will be zero inflation of average consumer prices. (If you happen to know about "nominal" and "real" dollars, this means you should think of your answers in "real" dollars. If you don't know what this means, don't worry about it.)"

Q3.2: Does your "second choice" vehicle get better or worse MPG than your current vehicle?

The possible responses to this question were "Better," "Worse," and "Exactly the Same."

"Absolute, Flow" Group

Q3.3AF: At the current [second fuel] price, how much money would be spent to buy [second fuel] for your "second choice vehicle"?

"Relative, Flow" Group

Q3.3RF: Compared to your [current vehicle], how much more or less money would be spent to buy [second fuel] for your "second choice vehicle"?

"Absolute, Total" Group

Q3.3AT: How much money would be spent to buy [second fuel] for your "second choice vehicle" over the next [future ownership period] that you might own it?

"Relative, Total" Group

Q3.3RT: Compared to your [current vehicle], how much more or less money would be spent to buy [second fuel] for your "second choice vehicle" over the next [future ownership period] that you might own it?

In all groups in Parts 3 and 4, the instructions also said, "Include money spent by you and by others for fuel for the vehicle. Assume that you drove it the same amount as your current vehicle. Just give your best guess."

1.1.4 Part 4

In Part 4, respondents were asked about the counterfactual fuel costs if they instead owned a "replacement vehicle" that was the same as their current vehicle except that it got different fuel economy. The MPG difference was randomly selected from the set $\{-10, -8, -7, -5, -3, -2, 2, 3, 5, 7, 8, 10\}$. The same two-by-two matrix of frames from Part 3 was maintained in this question, with similar wording. For example, for a respondent who owned a 22 MPG vehicle and was assigned an MPG difference of 3, Question 4.1AF would have read as:

The official rated miles per gallon (MPG) for your vehicle is 22 MPG. For this question, imagine that instead of your vehicle, you had a "replacement vehicle" that was rated 25 MPG. Because the "replacement vehicle" gets 3 MPG better than your vehicle, you would spend less on gasoline. At the current gas price, how much money do you think would be spent to buy gas for your "replacement vehicle"?

As in Q3.3AF and Q2.4F, respondents could choose to answer on a weekly, monthly, or yearly basis. Respondents were shown a table of seven vehicles, their pictures, and their MPG ratings, which is reproduced as Appendix Figure 1. In all conditions in Parts 3 and 4, respondents were also told to assume that they drove the alternative vehicle the same amount as their current vehicle.

1.2 Online Appendix II: Eliminating Outliers

A series of steps were taken to elicit true beliefs while eliminating any keying errors and thoughtless answers. First, during the survey itself, answers that were obviously internally inconsistent or improbably small or large were automatically flagged, and respondents encouraged either to confirm or rethink their answers. For example, in Q2.2F or Q2.3T, if a respondent entered that the current or expected future gasoline cost was more than \$10 or less than \$1 per gallon, the computer displayed: *"You responded that you think that regular gasoline will cost [X] per gallon. Please click "Next" if that is correct, or make a change if it is not correct."* If in Q2.3F or Q2.4T, the respondent reported spending more than \$25,000 or less than \$100 per year on gas costs, the computer displayed: *"You responded that [X] is spent on [fuel]. Please click "Next" if this is correct, or make a change if it is not correct."*

As a further example, if the respondent reports that his second choice vehicle gets worse MPG but entails lower gas costs, the computer displayed: *"Earlier, you said that you think that your "second choice vehicle" gets worse MPG than the vehicle you own. This means that that your "second choice vehicle" uses more gasoline per mile than the vehicle you own. But then you said that you would have spent less money on gasoline if you instead owned the second choice and drove it the same amount. Please go back and change."*

The second step was to manually change responses that were obvious keying errors. This was done in 23 cases, most commonly when it was clear that the respondent had accidentally added or omitted one or two zeros.

The third step was taken upon the observation that some respondents who were in the "Relative" frame appeared to answer Parts 3 and 4 as if they were giving a total amount. For example, instead of saying that they would save \$300 with a vehicle that was 8 MPG better, these respondents appeared to enter the total amount, say \$1200, that they would spend if they owned that vehicle - as if they were in the "Total" frame. To correct this, I generated the implied annualized fuel cost for Parts 3 and 4 based on the response to Part 2. For respondents in the Relative frame, I then generated the annualized fuel cost as if the respondent correctly interpreted the question and as if the respondent incorrectly gave the total amount that would be spent. I then proceeded with the analysis using the answer that was closest to the correct answer. This changed 195 answers to Part 3 and 140 answers to Part 4.

Fourth, some respondents in the "Relative" frame answered in Q3.2 that they believed that their second choice vehicle had better (worse) fuel economy but then checked a box in Q3.3 that implied that fuel expenditures would be higher (lower) by some amount. They then persisted with

this answer despite the computer-generated flag detailed in step 1 above. Analogous mistakes were made in Part 4. To correct this, I assumed that the respondent correctly knew whether the second choice vehicle in Part 3 and the "replacement vehicle" in Part 4 had higher or lower MPG and thus whether the fuel costs would be lower or higher. This changed 16 answers to Part 3 and 66 answers to Part 4.

Fifth, responses to Part 3 and 4 that were substantially different from the true values implied by responses to Part 2 were flagged and not used. Specifically, answers were flagged if they were too high or too low by more than a factor of five, or if they were too high or too low by more than a factor of three and the implied true annualized fuel cost was greater than \$1500. This eliminated 412 answers to Part 3 and 171 answers to Part 4. The outlying data eliminated through this procedure are illustrated by the "P3 Cost Flag" and "P4 Cost Flag" points in Online Appendix Figure A2.

Sixth, cases were flagged if responses to Part 2 implied less than 108 vehicle-miles traveled per year, the first percentile of the distribution of annualized odometer readings in the National Household Travel Survey data, or more than 200,000. This flagged 123 cases, which were not used in the belief estimation. These cases are illustrated by the "P3 VMT Flag" and "P4 VMT Flag" points in Online Appendix Figure A2.

Seventh, individual answers to 18 additional cases were flagged manually for various reasons, typically because they appeared to have made a keying error, but their original intent was not obvious.

After these flags were generated, cases were dropped entirely for two reasons. First, five cases were dropped entirely because of obviously careless answers. Second, 15 cases were dropped entirely because they had been flagged for the implied vehicle-miles traveled and for their responses to both Parts 3 and 4. These twenty cases were excluded before the sample weights were assigned.

There are both Type I and Type II errors in this process. On the one hand, some keying errors may not have been identified, introducing error into my measure of the respondent's beliefs. On the other hand, this procedure may have removed responses that appear unusual but reflect true beliefs. The process was designed to give the most reasonable measure of respondents' true beliefs.

1.3 Online Appendix III: Reporting Errors

Deviations of ϕ from unity can be divided into two categories: consumers' misperceptions and survey reporting errors. Reporting errors would result if respondents round their answers, misunderstand the survey, do not exert effort to respond correctly, or do not correctly recall previous beliefs. It is not clear why reporting errors could spuriously generate the evidence of MPG Illusion that will be observed in the data. However, it may be helpful to test for evidence of potential reporting errors in order to understand the credibility of the VOAS belief elicitation.

1.3.1 Survey Format and Framing

One concern with comparing elicited beliefs to true values is that respondents could be confused about the questions or the survey format. The analyst could then misattribute confusion about the survey to misperception of fuel costs. For example, a response could be required in units that differ from how people naturally store the value: if people were asked people how many centiliters of gasoline they thought their current vehicle used per hour, the analyst would likely conclude that respondents are highly misinformed. One way in which the VOAS addressed this was to allow the "Flow" group to report gasoline costs "per week," "per month," or "per year." Almost two-thirds of the "Flow" group reported weekly fuel costs, while one-third chose to give their answers on a monthly basis, and only three percent responded in dollars per year.

Between the Total and Flow frames, the Absolute and Relative frames, and the three time units in the "Flow" frame, the questionnaire has $2 \times 2 \times 3 = 12$ different ways of eliciting beliefs about fuel costs. Because there are a number of different frames, it is more likely that respondents will easily understand at least several. If the level and variance of ϕ is not significantly different across these frames, this supports the idea that the questions were clearly understood.

Online Appendix Table A3 presents the results of regressing ϕ_{ia} and $[\phi_{ia}^2 - \bar{\phi}]$ on a set of independent variables. Intuitively, this tells us how much the mean and variance of ϕ scale with each regressor. The first two regressors are indicator variables for the Total and Relative groups. The data show that the mean and variance of ϕ are not significantly different across the different frames. Furthermore, the coefficient on the "Second Choice ϕ " variable shows that the variance of ϕ is not statistically different for beliefs elicited for the second choice vehicle in Part 3 vs. the replacement vehicle in Part 4. As we saw in Table 2, however, the mean ϕ from Part 3 is smaller than the mean for Part 4.

The regressions also include a control for the absolute value of the difference in MPG between the current vehicle and replacement vehicle. The coefficient in Column (1) shows that people tend to overestimate the fuel cost differences between similar vehicles. The coefficient in Column (2) shows that valuation ratios are noisier for pairs of vehicles that are more similar.

1.3.2 Respondent Effort

A second potential concern is respondent effort: people might understand the questions and have accurate beliefs but have no incentive to type them in during the survey. It was for this reason that the Incentive and Non-Incentive groups were included. There is a tension in this type of belief elicitation between wanting to induce sufficient effort to report the beliefs that had existed at the time of choice and not wanting to induce additional information gathering or computational effort beyond what happened at that time. Therefore, it was intentionally left vague how the financial incentives would be scored, and the moderate incentive levels in the VOAS were deliberately set well below the level of being incentive compatible. Online Appendix Table A3 suggests that lack of

respondent effort did not statistically increase the extent of misperceptions, as the Incentive Group did not have statistically different variance in ϕ .

As discussed in Allcott (2011), a question appended to the end of the VOAS provides additional evidence on how effort in the survey compares to effort at the time of choice. The question read, *"In this survey, we asked you to calculate fuel costs fairly mathematically and precisely. Think back to the time when you were deciding whether to purchase your vehicle. At that time, how precisely did you calculate the potential fuel costs for your vehicle and other vehicles you could have bought?"* All but three percent of respondents calculated fuel costs as precisely or more precisely during the survey than they did at the time of choice. This strongly suggests that the misperceptions observed in the VOAS are not simply an artifact of low respondent effort.

1.3.3 Recall Error

A third potential concern is recall error. Respondents might understand the survey questions and might have had correct beliefs at the time of choice and be willing to report them faithfully, but they may not accurately recall the beliefs that the survey attempts to elicit. While this is theoretically plausible, there is little quantitative support for it: in Online Appendix Table A3, Years Since Purchase is not statistically significantly correlated with the variance in ϕ . As another data point, just under two thirds of all respondents correctly know whether their second choice vehicle gets better, worse, or the same fuel economy as their current vehicle. Sixty-five percent of people who bought more than one year ago are correctly informed, compared to 67 and 68 percent, respectively, of people who bought less than 12 and 6 months ago.

Online Appendix Table A1: Characteristic Balance in Framing Groups

	Total	Relative	Incentive	MPG Difference
	(1)	(2)	(3)	(4)
Income	-8.03e-07 (3.71e-07)**	-3.03e-07 (3.64e-07)	2.04e-07 (3.63e-07)	3.51e-07 (4.00e-06)
Education (Years)	0.0106 (0.0065)	-.0006 (0.0066)	0.0059 (0.0065)	-.0161 (0.0787)
Age	0.0016 (0.001)	-.0002 (0.001)	0.0012 (0.001)	-.0030 (0.0134)
Male	-.0126 (0.0288)	0.0345 (0.0291)	-.0228 (0.0289)	0.0571 (0.3654)
Household Size	0.0066 (0.011)	-.0092 (0.0111)	0.0144 (0.0109)	-.2528 (0.1429)*
Liberal	-.0125 (0.0098)	-.0064 (0.0098)	-.0099 (0.0097)	0.2358 (0.1234)*
Rural	0.0274 (0.0385)	0.0012 (0.039)	0.067 (0.0391)*	-.4806 (0.4543)
Const.	0.3476 (0.1242)***	0.5723 (0.1241)***	0.3482 (0.1225)***	0.4649 (1.5078)
Obs.	2114	2114	2114	2007
<i>F</i> statistic	1.5481	0.5374	1.267	1.2281
F-test p-Value	0.1466	0.8066	0.2628	0.2835

Notes: Weighted for national representativeness. Robust standard errors in parenthesis. *, **, ***: Statistically significant with 90, 95, and 99 percent confidence, respectively. The Liberal score is self-reported political ideology normalized to mean zero, standard deviation one, with lower being more conservative and higher being more liberal.

Online Appendix Table A2: Robustness of Table 2 to Recall Error

Part 3: Second Choice Vehicle ϕ

	All	$ \Delta \text{ GPM} > 0.1$	$ \Delta \text{ GPM} \leq 0.1$	$\phi \neq 0$
	(1)	(2)	(3)	(4)
Mean	0.87 (0.12)	1.03 (0.07)	0.80 (0.18)	1.05 (0.26)
Years Since Purchase	-0.004 (0.02)	-0.02 (0.01)*	0.003 (0.03)	0.01 (0.04)
$\log(\text{Income}) - \overline{\log(\text{Income})}$	-0.19 (0.09)**	0.01 (0.05)	-0.31 (0.14)**	-0.36 (0.19)*
Median	0.79 (0.12)*	0.85 (0.08)*	0.44 (0.25)**	1.22 (0.17)
Years Since Purchase	-0.02 (0.02)	-0.009 (0.01)	-0.01 (0.04)	0.006 (0.03)
$\log(\text{Income}) - \overline{\log(\text{Income})}$	-0.07 (0.09)	0.03 (0.06)	-0.25 (0.19)	-0.02 (0.13)
Obs.	1379	452	927	649

Part 4: Replacement Vehicle ϕ

	All	$ \Delta \text{ GPM} > 0.1$	$ \Delta \text{ GPM} \leq 0.1$	$\phi \neq 0$
	(1)	(2)	(3)	(4)
Mean	1.33 (0.07)***	0.88 (0.04)***	1.91 (0.13)***	2.01 (0.14)***
Years Since Purchase	-0.004 (0.01)	0.01 (0.006)**	-0.03 (0.02)	-0.03 (0.02)
$\log(\text{Income}) - \overline{\log(\text{Income})}$	-0.08 (0.05)	-0.02 (0.03)	-0.25 (0.11)**	-0.30 (0.11)***
Median	0.99 (0.02)	0.81 (0.05)***	1.32 (0.05)***	1.34 (0.05)***
Years Since Purchase	0.004 (0.004)	0.01 (0.007)**	-0.008 (0.007)	-0.003 (0.008)
$\log(\text{Income}) - \overline{\log(\text{Income})}$	-0.03 (0.02)	-0.03 (0.04)	-0.20 (0.04)***	-0.19 (0.04)***
Obs.	1828	975	853	808

Notes: Excludes flagged observations. Weighted for national representativeness. Robust standard errors in parenthesis. *, **, ***: Statistically different from one with 90, 95, and 99 percent confidence, respectively. Replicates Table 2 exactly except also controls for Years Since Purchase and deviation from average $\log(\text{Income})$. Observation count slightly different from Table 2 due to a small number of missing observations of Years Since Purchase and $\log(\text{Income})$.







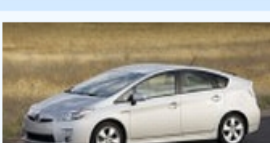
Online Appendix Table A3: Mean and Variance of Valuation Ratios

	Mean	Variance
	(1)	(2)
Relative Cost Group	0.11 (0.13)	-1.72 (2.95)
Total Cost Group	0.02 (0.13)	1.21 (2.86)
Incentive Group	-1.13 (0.13)	-1.37 (2.97)
Years Since Purchase	-.005 (0.02)	-.21 (0.31)
Second Choice ϕ	-.49 (0.14)***	3.97 (2.84)
Current-Alternative Vehicle MPG	-.06 (0.02)***	-1.40 (0.38)***
Const.	1.67 (0.23)***	13.35 (6.90)*
Obs.	3207	3207
F statistic	8.79	9.23
R^2	0.02	0.01

Dependent Variables: ϕ in Column (1), $[\phi_i^2 - \bar{\phi}^2]$ in Column (2)

Notes: Excludes flagged observations. Weighted for national representativeness. Robust standard errors in parenthesis, clustered by respondent i . *, **, ***: Statistically significant with 90, 95, and 99 percent confidence, respectively.

Online Appendix Figure A1: Table of Example MPG Ratings in Part 4

Example Vehicles and MPGs		
Vehicle	Picture	MPG (Combined City/Highway)
2010 Chevy Suburban 1500. 8 Cylinder, 6.2 Liter Engine with Automatic Transmission and Rear-Wheel Drive		14
2010 Ford F-150. 8 Cylinder, 4.6 Liter Engine with Automatic Transmission and Rear-Wheel Drive		16
2010 Subaru Outback Wagon. 6 Cylinder, 3.6 Liter Engine with Automatic Transmission and All-Wheel Drive		20
2010 Chevy Malibu. 4 Cylinder, 2.4 Liter Engine with Automatic Transmission and Front-Wheel Drive		25
2010 Honda Civic. 4 Cylinder, 1.8 Liter Engine with Automatic Transmission and Front-Wheel Drive		29
2010 Ford Fusion Hybrid. 4 Cylinder, 2.5 Liter Engine with Automatic Transmission and Front-Wheel Drive		39
2010 Toyota Prius Hybrid. 4 Cylinder, 1.8 Liter Engine with Automatic Transmission and Front-Wheel Drive		50

Online Appendix Figure A2: Outliers and Retained Data

