*BUMPY DESIGNS: IMPACT OF PRIVACY AND TECHNOLOGY COSTS ON SUPPORT FOR ROAD MILEAGE USER FEES**

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Abstract

The mileage user-fee is a promising alternative to the fuel tax but public opposition is a barrier to implementation. We use a large nationally representative survey with an embedded experimental design to determine the extent to which key design features (technology costs and perceived invasion of privacy) influence public opinion regarding the adoption of mileage user-fees. Our findings confirm widespread opposition of mileage user-fees; the ratio of opponents to supporters is about four to one. The embedded experiment provides evidence that public opposition can be attenuated somewhat through two design features: insulating motorists from a new one-time cost for GPS technology to measure mileage, and safeguards that eliminate or minimize perceived invasions of privacy. Future research should explore additional design innovations that can minimize public opposition to this promising source of public revenue.

Keywords: mileage road user-fee; fuel tax; highway financing; public opinion.

JEL Codes: H2, H4, H54, R4

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I. INTRODUCTION

The fuel tax has grown increasingly inadequate as a means of financing road infrastructure in the United States due to a fuel tax that is not adjusted for inflation in the cost of road construction and repairs, and enhanced vehicle fuel economy, which reduces fuel consumption (Wachs, 2007, Duncan and Graham 2013). The annual tax revenue generated by the federal fuel tax is more than $20 billion lower than the $54 billion required each year to maintain highway performance at its current level (Kile, 2011). The shortfall is even more dramatic when one considers the level of expenditures required to finance all road infrastructure projects that pass a standard benefit-cost test. An annual investment of $220 billion through 2040 will be required to maximize net benefits from spending on highways, bridges and transit infrastructure (ASCE, 2011). Similar shortfalls exist at the state level. For example, a panel of experts in Colorado found that the state would face a funding gap of $51 billion by 2030, even if the state settled for simply sustaining the current transportation system (Ungemah et al., 2013).[1]

With revenues falling and construction, maintenance and repair costs increasing, governments across the country have been searching for solutions. One solution is the use of a mileage user-fee, which – in its simplest form – is a charge for each mile of vehicle travel (Associated Press, 2009; Kost, 2009; Sorensen et al., 2010-11).[2] This solution is seen as promising by some transportation and public-finance authorities because of its revenue-raising capability and its respect for the benefit principle (i.e., those who use the roads should pay for their maintenance and repair) (Wachs, 2007; Kost, 2009; Duncan and Graham, 2013). However,

[1] Existing evidence points to similar funding shortages in other states: for example, New York (Peters and Gordon 2009), Alabama (Sisiopiku 2006) and New Mexico (Cambridge Symantics Inc., 2007).
[2] Another short term effort includes the reliance on federal stimulus funds, which has played a non-trivial role in the not too distant past (Hanak, 2009).

adoption has been slow. Oregon is the only state to adopt a mileage user-fee and only on a small voluntary scale; a maximum of 5000 people can volunteer to participate in the program.

A key obstacle to enactment of a mileage user-fee is that the idea is unpopular. For example, Duncan et al. (2014a) finds widespread opposition to both state and federal mileage user-fees. They also find that the intensity of opposition is much stronger than the intensity of support. Agrawal and Nixon (2013) reviewed 15 national and state surveys administered from 2006 to 2012 and found that, despite some variation in how the support/opposition question is asked, a majority of respondents – often more than 75 percent – is opposed to the enactment of a mileage user-fee to fund highway and/or transportation projects. The surveys examined by Agrawal and Nixon vary in how the mileage user-fee is described – some are vague in describing how the mileage would be determined and how the fee would be collected, some refer to a new tracking device installed in the car, some refer to paying at the pump for miles driven since the previous fill-up, and some refer to paying at the owner's annual vehicle inspection.

In their own work, Agrawal and Nixon (2013) show that the popularity of mileage user-fees is influenced by specific design features. They find that only 19 percent of respondents support a flat-rate mileage tax of one cent per mile while 39 percent of the same respondents support a mileage fee that varies by the vehicle's pollution level but averages out to one cent per mile. With the exception of the pollution-adjusted fee, specific design features of the mileage user-fee have not been analyzed rigorously for their impact on public opinion.

We begin to fill this gap in the literature by exploring additional design features of the mileage fee that may affect the degree of public support/opposition. In particular, we extend the work of Duncan et al. (2014a) to investigate how public opinion is influenced by two concerns: privacy and technology costs. Switching to a mileage user-fee requires measuring and reporting

the mileage of each vehicle on a regular basis, a process that can raise privacy concerns. Additionally, any one-time cost of installing special tracking devices in vehicles may trigger some public opposition, especially since vehicles are already equipped with odometers.

Based on results from focus groups and anecdotal review of media coverage, we hypothesize that respondents will be less likely to oppose a mileage user-fee if they do not have to pay the costs (equipment and installation) for a new tracking device (e.g., a GPS system) in their vehicle. We also hypothesize that respondents will be more likely to support a mileage fee that is designed in ways that minimize concerns about potential privacy invasions (e.g., opposition may arise if the government can electronically monitor when and where a motorist is traveling). Our research objective, then, is to identify the impact of technology cost and privacy concerns on public attitudes toward mileage user-fees. We do not explore other design features that are also likely to influence public opinion such as the size of the fee, adjustments to the fee based on vehicle weight and/or road type, and use of premium fees to reduce congestion in urban areas.

Our data on public opinion are drawn from the IU-SPEA Mileage User-Fee Survey that was administered in the summer of 2013. The survey elicited public opinion about state-level mileage user-fees from 2087 individuals who are weighted to be representative of the non-institutionalized United States adult population. The survey has an embedded experimental design aimed at determining whether specific design features of a mileage user-fee, particularly features related to technology cost and privacy concerns, are associated with public support/opposition of a mileage user-fee.

The article reports several key findings. First, we confirm widespread public opposition to enactment of a mileage user-fee, with the number of opponents exceeding the number of

supporters by almost four to one (79 percent oppose; 21 percent support). Second, and perhaps most interestingly, we find that the degree of public support for a mileage user-fee is related significantly to design features of the fee: specifically, to the potential cost of GPS systems for monitoring mileage, and privacy concerns about the government collecting mileage information. Although the vast majority of respondents oppose the fee regardless of how it is designed, our key finding is that support is enhanced by design features that minimize new technology costs (for vehicle owners) and minimize the potential for invasion of privacy.

The results from this study contributes to a small but growing literature on mileage user-fees and road financing more broadly. One strand of research explores mileage fees for congested areas (Verhoef et al., 1997). Some reports examine the mileage fee in comparison to other possible revenue sources (Sisiopiku et al., 2006; Peters and Gordon, 2009; Agrawal and Nixon, 2013). The distributional impacts (on different income classes) have been investigated (West, 2005; Zhang et al., 2009; McMullen et al., 2010; Weatherford, 2011). Walls and Hanson (1999) explores distributional implications of mileage user-fees as a policy to reduce vehicle emissions. Several states have commissioned studies or pilot projects to examine the feasibility of the mileage user-fee (Sorensen et al., 2010; Hanley and Kuhl, 2011; Ungemah et al., 2013).[3] A variety of approaches to collecting mileage information and fees have been analyzed from the perspectives of technical feasibility, administrative practicality, and potential for evasion (Sorensen, 2009).

The two studies most closely related to ours are Agrawal and Nixon (2013) and Duncan et al. (2014a). Agrawal and Nixon (2013) collect public opinion on a federal mileage user-fee that is administered with a third-party tracking device and either a flat rate or a rate that varies by

[3] For example, Oregon and Minnesota have conducted pilot studies. The University of Iowa conducted a large scale pilot study in 12 cities across six states. Washington State, Indiana and Colorado are among a list of other states that have or are considering mileage user-fee pilot studies.

vehicle emissions. Although Duncan et al. (2014a) focus on a state level mileage user-fee and use the same data source as we do, they do not explore the impact of policy design features. Instead, their aim is to identify the level and intensity of support for mileage user-fees. Therefore, our paper differs from Agrawal and Nixon (2013) in that we explore privacy and cost while they explore rate structure, and differs from Duncan et al. (2014a) in that we look at design features while they look at level and intensity of support.

Our findings suggest that it is important that mileage user-fee policy proposals minimize technology costs to vehicle owners and are designed such that mileage information receives the highest level of privacy protection. Additionally, steps must be taken to convince the public that privacy safeguards will be implemented and enforced. Although we find that these design features are especially important for people who are favorably disposed to the implementation of mileage user-fees, we cannot rule out their importance for people who are opposed. We therefore argue that these two features should be central to any proposed mileage user-fee.

We also see our results as evidence that policymakers ought to consider additional pilot studies aimed at identifying design features of user-fees that are more acceptable – or at least less offensive - to the public. Although our research approach provides useful insights into the potential impact of technology cost and privacy on support for mileage user-fees, reliance on public opinion surveys must be seen as a first step in understanding the best way to design mileage user-fees. Appropriately designed pilot studies across multiple states is the next logical step in this effort to understand how best to design mileage user-fees. The design of such fees is especially important given that securing adequate funds for highways and transportation is a major challenge for the public sector throughout the world. Additionally, public opposition to taxation is solidifying, thus making it difficult for public authorities to provide the needed level

of public goods. Having a clear understanding of how best to design a mileage user-fee – or other revenues sources – will make it easier for policy-makers to raise the revenue needed to provide these services.

The remainder of the paper is organized as follows. Section II describes the data, Section III describes the empirical strategy of the study and Section IV describes the results. Section V summarizes the main findings and policy implications.

II. DATA

The data are taken from a public opinion survey that was designed and sponsored by the Indiana University School of Public and Environmental Affairs and conducted in August and September 2013 by GfK Custom Research. This section of the paper provides a brief description of the survey and summary statistics of the key variables. Because the focus of this paper is on the role of privacy and technology-cost concerns in determining public support for mileage user-fees, we only describe those features of the survey that enable us to answer our research question. A more detailed description of the survey is provided in Duncan et al. (2014a).

A. Description

Privacy The survey instrument includes a series of questions on road mileage user-fees that differ in the extent to which they could potentially invade privacy. Participants are first asked to state whether they agree or disagree with several statements that cover privacy, technology cost, compliance issues and fairness characteristics of a general mileage user-fee.[4] They are then asked to state whether they would support or oppose a policy that replaced the gasoline tax in their state with a mileage user-fee. The specific question is:

> *Would you be in support of or opposed to **replacing** the gasoline tax in your state with a mileage user-fee?*

[4] A complete list of the statements is presented in the appendix.

The objective of this question is to elicit a baseline measure of individuals' willingness to support mileage user-fees. As such, participants are not provided with any administrative details at this stage of the survey instrument. We refer to this as the *general* mileage user-fee mode.

We repeat this series of questions for three alternative modes of administering the mileage user-fee: odometer, basic GPS and advanced GPS. First, we describe the administrative details of the odometer mode. Participants are told they would have to report their mileage to the department of motor vehicles either in person or online and that they would be able to make their user-fee payments monthly, quarterly or annually. They are also told that 10 percent of drivers in their state would be randomly chosen for inspection annually and that underreporting mileage and odometer tampering would be punished by a fine and/or prison time. After reading the administrative details of the odometer mode, participants are asked to state whether they agree or disagree with six statements about the odometer-based mileage user-fee. These statements cover issues of privacy, technology cost, convenience, compliance and fairness. This is followed by a question asking whether they would support or oppose replacing the gasoline tax in their state with the odometer based mileage user-fee they had just reviewed. Again, the specific question used is:

> *Would you be in support of or opposed to **replacing** the gasoline tax in your state with a mileage user-fee based on odometer readings?*

After responding to the questions on the odometer mode, participants then respond to a similar set of questions on two types of GPS-based mileage user-fees. We refer to the first type of GPS mode as a basic GPS. Participants are told that a GPS device would be installed in their vehicles and that the GPS device would only collect data on the number of miles driven. It is clearly stated that no location data would be collected. The other features are identical to the odometer mode: frequency of payment, inspection and fines for underreporting and tampering.

What we refer to as the advanced GPS mode is identical to the basic mode except that the device would collect location data: when and where miles are driven.

Every participant responded to questions about the general mode and then the odometer mode, before being randomly selected to answer questions about the basic GPS and then advanced GPS or the advanced GPS and then the basic GPS. Participants responded to the questions using a four-point scale that allows us to determine intensity of support/opposition or agreement/disagreement.

Cost Because we are interested in the impact of technology cost on the willingness to support mileage user-fees, we include a cost-related experimental design feature in the questionnaire. All participants are told that the cost of the GPS device and its installation is $250. However, a random half of the participants are told that they would have to pay for the GPS device and its installation (*driver pays* subsample) and the other half are told that the government would cover the cost (*government pays* subsample). Those participants who would have to pay for the device are also told that they would be permitted to pay the one-time cost (of the device and installation) over three years.

Other Questions The questionnaire includes a number of other questions besides those related to privacy and cost. We collect data on perceived conditions of roadways, need for new or updated roads and opinion on how the cost of road financing should be distributed. For the latter variable, we ask participants four questions about who they believe should pay for road maintenance, repairs and construction. Participants' responses to these four questions are used to create an indicator variable that is equal to one if a participant believes that the cost of financing roads should be distributed according to road use (Duncan et al., 2014b). We also collect data on the number of vehicles owned, the fuel economy of vehicles, the number of miles driven and

usage of interstates and public transportation. Additional data on individual socioeconomic, demographic and political characteristics are provided by GfK. These include age, sex, marital status, income, employment status, education, party affiliation and ideology.

B. Representativeness of the Sample

The web survey was fielded to a nationally representative sample of 3325 United States adults 18 years of age or older from GfK's KnowledgePanel®. The KnowledgePanel® is a probability-based online panel. Members are recruited using random-digit dialing and address-based sampling methods that include both households with and without internet access, thus providing nearly complete coverage of the United States population. Probability-based internet panels have advantages compared to random-digit dialing telephone surveys and other methods, including the potential for reduced measurement error, lower cost and increased timeliness (Yeager et al., 2010).

The survey was fielded from August to September 2013. Five reminders to encourage participation were sent to non-respondents during this time period. We obtained 2142 respondents for an American Association for Public Opinion Research Completion Rate (COMR) of 64 percent among panel members. Approximately 2.5 percent of respondents (55 respondents) were removed from the sample due to short survey completion time: less than six minutes.[5] Short response time is an indicator that survey researchers commonly use to identify speeders who complete the survey without reading and carefully answering the items (Olson and Parkhurst, 2013). This leaves us with a sample of 2087 respondents.

[5] A tabulation analysis showed that respondents who take fewer than six minutes to complete the survey have responses that are different from the remainder of the sample on a number of important variables (results available upon request). Given the length of the survey, it is also unlikely that anyone could have read all of the items and answered thoughtfully in this short period of time. Respondents in the six to 10 minute range are very similar to respondents who take a longer time to complete the survey. For these reasons, we excluded respondents in the one to five minute range.

Data have been weighted to adjust for unequal probabilities of selection and to reflect Current Population Survey estimates of the United States population on demographic characteristics, including age, sex, race/ethnicity, education, household income, home ownership status, internet access, Census region and metropolitan area status. The final weighted distribution of respondents in our sample compares favorably with the 2013 estimates from the Current Population Survey, thus confirming that our sample is representative of the non-institutionalized United States adult population. We also find that each subsample – *government pays* and *driver pays* – is balanced along individual characteristics, suggesting that randomization into sub-groups worked well (results available upon request). Summary statistics for all covariates are presented in Table 1.

III. EMPIRICAL STRATEGY

Our objective is to identify the extent to which privacy and technology costs affect willingness to support mileage user-fees. This section of the paper describes the empirical strategies used to address this issue.

A. Predicting Support

We exploit two experimental features of the survey design in order to identify the impacts of privacy and cost. First, we collect data on each participant's willingness to support or oppose a basic GPS-based mileage user-fee and an advanced GPS-based mileage user-fee, using a four-point scale. We then convert the scale to a binary measure of support that takes a value of one if an individual either supports or strongly supports the mileage user-fee and zero otherwise. We use this binary measure of support as our dependent variable. Because the two GPS modes are identical except for the explicit use of the advanced GPS mode to track when, where and number of miles driven, we take the difference in the share of participants who support these two modes

as an estimate of the impact of privacy on willingness to support a mileage user-fee. This interpretation is consistent with the opinions of focus group respondents for whom privacy concerns appeared to be paramount, but we cannot rule out the possibility that some respondents had non-privacy concerns (e.g., collection and maintenance of location information is unnecessary, costly and complicated to administer).

Second, each participant is randomly assigned to one of two groups that are identical except for how the cost of the GPS unit ($250) is distributed; *driver pays* and *government pays*. Since participants are randomly assigned to groups and the groups are identical except for the distribution of GPS costs, any difference in willingness to support the GPS-based mileage user-fee between the two groups can be attributed to cost. We exploit this design feature of the survey parametrically by estimating the following model:

$$S_{im} = \alpha + \theta \cos t + \gamma\, order + \beta X_i + \delta Z_{im} + \varepsilon_{it}, \qquad (1)$$

where *S* is a dummy variable that takes a value of one if support and zero if oppose the mileage user-fee indicated by mode *m*, *cost* is equal to one if a participant is in the *driver pays* group and zero if the participant is in the *government pays* group. Given randomization into cost groups – *government pays* or *driver pays* – the estimated coefficient on the *cost* variable represents the causal effect of cost on willingness to support mileage user-fees. Although the two groups are randomly determined, we include additional covariates to account for possible omitted variable bias. These include *order*, which is equal to one if individuals respond to the basic GPS mode before the advanced GPS mode; *X*, which is a vector of individual demographic, socio-economic and political characteristics such as age, sex, race, party affiliation, region and employment status; and *Z*, which is a vector of mileage user-fee specific characteristics that capture privacy concerns. Subscripts *i* and *m* indicate individuals and mode of mileage user-fee, respectively.

The model is estimated separately for the basic and advanced GPS modes, respectively. Because the dependent variable in (1) is binary, we assume the cumulative density function is logistic and estimate a logit model; estimation is with robust standard errors and sample weights.[6]

B. Predicting Transition

We extend the previous analysis by predicting the probability of transition from support to oppose. Each participant was asked to state his willingness to support a general mileage user-fee and an odometer based mileage user-fee, before responding to the GPS-based modes. The general question offers very little information about the way in which the user-fee would be administered. The other three user-fee questions add detailed information on the mode of administration and differ in the technology employed to collect mileage, extent to which privacy may be invaded and the cost of technology to the user.

Because the odometer mode does not require the use of a third-party tracking device, we hypothesize that drivers are likely to perceive it as being the least invasive of the modes. This assumption is supported by evidence gathered from the survey; while 68 percent of participants believe an odometer-based mileage user-fee would be invasive, approximately 81 percent believe an advanced GPS based system would be invasive. The basic GPS mode entails a tracking device, but it only records the number of miles driven and may therefore be perceived as less invasive than the advanced GPS, which also tracks when and where miles are driven.

We estimate transitional probabilities in two ways: count method and parametric model. The first step of the count method is to count the number of participants who support replacing the gasoline tax with the *general* mileage user-fee. Next, we count the number of participants

[6] We also estimate the model using the cloglog specification to account for the fact that more than 75 percent of the sample oppose the mileage user-fee. This does not affect the results.

who oppose each mode of administration, separately, conditional on having supported the *general* mileage user-fee. These individuals are called *switchers* and they are indicated by the variable O_{im} that takes a value of one if individual *i* opposes administration mode *m* conditional on supporting the *general* mileage user-fee; *m* refers to the odometer, basic GPS or advanced GPS modes of administration.

The logic behind this approach is as follows. If privacy is a concern, then we would expect the share of odometer switchers to be lower than the share of GPS switchers, and the share of advanced GPS switchers should be the highest. Additionally, the difference between the share of basic GPS switchers and advanced GPS switchers is an estimate of the privacy effect. The difference between the share of odometer switchers and GPS switchers may also be taken as a measure of the privacy effect. However, this measure is most likely confounded by other differences between the odometer and GPS modes such as cost and convenience.

The cost effect is obtained by dividing the sample into two groups based on who pays for the GPS device and its installation. We then count the number of switchers for each sample and each GPS mode. Consider the basic GPS mode, for example. We count the number of individuals in the *driver pays* sample who oppose the basic GPS mileage user-fee conditional on having supported the *general* mileage user-fee. This method is repeated for the *government pays* subsample. Since individuals are randomly assigned to these groups and the only difference between these two groups is who is responsible for covering the cost of the GPS device, any difference in the share of switchers must be due to the cost of the device. We are also able to exploit these subsamples to get another estimate of the privacy effect. In particular, we can compare the share of odometer switchers with the share of basic GPS switchers in the *government pays* subsample. This strategy is repeated with the advanced GPS mode. Comparing

odometer switchers with GPS switchers in the *government pays* subsample removes the impact of out of pocket technology costs and should therefore provide a relatively clean estimate of the privacy effect.

The count method is extended in a parametric framework by estimating (2).

$$O_{im} = \alpha + \varphi \cos t + \lambda\, order + \sigma X_i + \phi Z_{im} + \varsigma_{it}\,, \qquad (2)$$

where all covariates are as defined before. This allows us to control for individual characteristics that may affect the probability of switching.

IV. RESULTS AND POLICY IMPLICATIONS

This section of the paper describes our findings. We begin with summary statistics of the level of support for the various modes of administering the mileage user-fee. We then present results from our empirical models that identify the impact of cost and privacy on the willingness to support mileage user-fees, and switchers.

A. Predicting Willingness to Support

The results presented in Table 2 show that approximately 21 percent of participants support replacing the gasoline tax with a *general* mileage user-fee. We find a similar level of support for the odometer-based mileage user-fee; the difference of 0.5 percentage points is both economically and statistically indistinguishable from zero. On the other hand, the level of support falls by six and eight percentage points for the basic and advanced GPS modes, respectively, relative to the *general* mode. These differences are large and statistically different from zero at the one percent significance level. As expected, we find that more participants support the odometer mode than either of the GPS modes. This is consistent with there being greater privacy and/or cost concerns with the GPS modes. Further evidence of a privacy concern is presented in column 4 of Table 2 where we show that the advanced GPS is the least preferred

mode. Because the GPS modes are identical except for the amount of information collected in the advanced mode, the two percentage point difference in support between the basic and advanced GPS modes is an initial indicator that privacy matters.

Since we are particularly interested in the impact of privacy and technology cost, we exploit the experimental design features of the survey instrument and estimate (1) separately for the basic GPS and advanced GPS mileage user-fees and report the results in Table 3. We find strong evidence that shifting the cost of the basic GPS instrument to vehicle owners reduces the probability of supporting the basic GPS mileage user-fee. The estimated coefficient in Panel A of model 1 is -0.480, which is statistically different from zero at the one percent level. The marginal effect of the estimated coefficient suggests that the probability of support of a basic GPS user-fee is -0.06 lower among participants who have to pay for the GPS device. This represents a 33 percent reduction in the share of supporters from the mean level of support in the *government pays* subsample.[7]

We also find that the estimated impact of cost on the probability of support remains the same even after controlling for individual demographic, socioeconomic and political characteristics (Model 2, Table 3) and perception of privacy invasion (Models 3 to 5, Table 3). We control for two measures of perceived privacy: data security against third-party access and monitoring by the government. The probability of support is lower among participants who are concerned that their mileage data will be easily accessed by people outside of the government and higher among participants who like that the basic GPS mode only tracks number of miles driven. Although the estimated effect of cost remains large and statistically different from zero,

[7] The level of support in the *government pays* subsample is 18 percent.

its marginal effect is approximately two to three times smaller than the effect of privacy concern.[8]

The results are similar in Panel B (Table 3) where we estimate the impact of cost on support for the advanced GPS mode. Again, both cost and privacy matter and privacy (risk of government monitoring location data) has a relatively larger effect than cost; the marginal effect of cost is -0.036 and the marginal effect of privacy is -0.165 (Model 5, Table 3). Interestingly, concern about third-party access to mileage data has no effect on the probability of support for the advanced GPS mileage user-fee when risk of the government monitoring location data is included in the model. The estimated coefficient reported in Panel B of Table 3, as well as the marginal effect, are indistinguishable from zero.

The order in which participants are exposed to the GPS modes appears to influence the probability of support. In particular, participants who responded to the basic GPS mode before the advanced GPS mode are less likely to support both types of GPS modes.[9] One possible explanation for this finding is that the basic GPS is more acceptable if the alternative is an advanced GPS mode with much higher privacy invasion possibilities. More importantly, the cost and privacy estimates reported in Table 3 are unaffected by the inclusion of individual socioeconomic, demographic and political characteristics. Tables A1 and A2 in the appendix report the complete results for all covariates.

We exploit the relationship between cost and privacy further by estimating (1) with an interaction term between technology cost and our two measures of perceived privacy invasion; people outside the government can access mileage data and the government can or cannot

[8] Looking at marginal effects, we find that having to pay for the GPS device reduces the probability of support by 0.043 in Model 5 of Panel A, Table 3. On the other hand, fear of unauthorized third-party access reduces the probability of support by 0.077 and the lack of location monitoring increases the probability of support by 0.134.

[9] Although the estimated coefficient on *order* is negative in Panel B, the estimate is not statistically different from zero.

monitor driver location. The results presented in the first and second columns of Panel A of Table 4 show that technology cost has a large effect on the probability of supporting a basic GPS mileage user-fee, regardless of perceived privacy invasion. Although the effect is slightly smaller in absolute terms among people with privacy concerns, the difference, which is given by the interaction term, is not statistically different from zero. Similarly, the impact of privacy is large, statistically different from zero, and statistically independent of who pays for the GPS device.

The cost estimates in the third and fourth columns of Panel A of Table 4 reflect the impact of technology cost among people with privacy concerns. These estimates are suggestive of impact, but are estimated with large standard errors. On the other hand, the impact of privacy in the *government pays* subsample is large, statistically different from zero and independent of who pays; the estimated interaction term is not statistically different from zero. The results in Panel B, Table 4 are qualitatively similar to those in Panel A: cost has an effect, but is imprecisely estimated; privacy has a large and statistically significant effect; and the interaction term is not statistically different from zero. The results suggest that the importance of privacy does not depend on who pays for the GPS device; both groups are equally likely to oppose the mileage user-fee on the grounds of privacy invasion.

B. Predicting Transition

In this section of the paper, we provide a more detailed analysis of the impact of privacy and technology costs on the willingness to support a mileage user-fee. The analysis exploits the privacy and cost differences between the modes by estimating the share of *switchers* for each

mode of administration.[10] We describe results based on the nonparametric count method as well as a more rigorous parametric logistic model.

1. Count Method

Panel A of Table 5 reveals that the mode of administration is irrelevant for people who oppose replacing the gasoline tax with a mileage user-fee. Approximately 94 to 95 percent of the people who oppose the *general* mileage user-fee also oppose the odometer, basic and advanced GPS mileage user-fees. It is clear that differences in the privacy implications of the various modes don't matter for these individuals. This does not imply that privacy is not a concern. In fact, one possible explanation is that privacy matters but these individuals simply do not believe there are any real differences in the privacy implications between these modes. It is also possible that people are simply objecting to the idea of a new fee. In other words, a new tax or fee is objectionable regardless of its privacy implications. Because we cannot distinguish between these alternative hypotheses, we focus our analysis of privacy and cost on *switchers*; people who oppose the various modes conditional on supporting the general mileage user-fee.

The behavior of switchers is shown in Panel B of Table 5 and reveals large privacy effects. Consider the first row of Panel B, conditional on supporting the general mileage user-fee, 20 percent of participants switch from support to oppose when faced with an odometer mileage user-fee.[11] This is 30 and 35 percentage points lower than the share of switchers for the basic GPS and advanced GPS modes, respectively. Because the GPS modes are identical except for details that affect privacy, the six percentage point difference in the share of switchers between these two modes is an estimate of the privacy effect among supporters of the mileage user-fee.

[10] Recall that odometer *switchers* are individuals who oppose the odometer mode conditional on supporting the general mileage user-fee. The basic and advanced GPS *switchers* are defined similarly.

[11] The numbers for the odometer mode are identical across rows within each panel of Table 6 and are therefore only shown once in each panel.

However, we argue that this estimate is a lower bound on the privacy effect because some participants may not trust that the government will use the basic GPS for monitoring miles and nothing else. In other words, to the extent that participants believe the use of any third party device represents an invasion of privacy, they may view the basic and advanced GPS modes as having the same impact on privacy. This is a reasonable possibility given the large share of people for whom the administrative details of the three modes doesn't affect willingness to support.

On the other hand, the 30 (35) percentage point difference between odometer and basic (advanced) GPS is most likely an upper bound of the privacy effect because privacy is only one of many differences between the odometer and GPS-based mileage user-fees. For example, the odometer and GPS modes differ in convenience, susceptibility to evasion, and start-up costs for vehicle owners. The perceived evasion differences seem too small to explain the large difference in the share of switchers. Table 6 shows that among respondents who support the general mileage user-fee, approximately 56 percent agree with the statement that vehicle owners would tamper with their odometers (when asked about the odometer mode). The same share (57 percent) agrees that people would tamper with the GPS device. We also find that roughly 62 to 65 percent of respondents agree that the audit process would reduce evasion in either the odometer or GPS modes.

Unlike evasion, there are big differences in perceived privacy, convenience, and technology cost (see Table 6). First, 47 percent of respondents who support the general mileage user-fee agree that it would be inconvenient to report odometer readings to their department of motor vehicles. But this rate is 16 percentage points lower than the share of respondents who

agree that the GPS installation would be inconvenient.[12] The GPS mode might be perceived as more convenient given the annual reporting required for the odometer mode. If true, then this consideration would bias the privacy effect downwards.

Second, among respondents who support the general mileage user-fee, 40 percent agree that a requirement to report odometer readings is an invasion of privacy. On the other hand, 66 percent dislike the advanced GPS mode because the government tracks when, where and how much people travel, and 81 percent like the basic GPS because it does not track location and time. Furthermore, 72 to 75 percent worry that someone outside the government will be able to access their GPS mileage data.

Finally, the start-up cost differences between odometer and GPS modes imply that the 30 percentage point difference between odometer and GPS switchers overestimates the privacy effect. We exploit the experimental design feature of the survey to eliminate the bias caused by the difference in costs between GPS and odometer modes. First, we divide each of the GPS modes into two groups based on who pays for the GPS device: *driver pays* and *government pays*. We then repeat the transition count procedure described above and present the results in the second and third rows of Panels A and B of Table 5.

Again, the results reported in the second and third rows of Panel A of Table 5 show that neither the mode of administration nor cost of monitoring matters for participants who oppose the mileage user-fee. Approximately 93 percent of those who oppose the general mileage user-fee also oppose the odometer, basic and advanced GPS modes when the *government pays*; the corresponding number when drivers pay is roughly 95 percent. On the other hand, privacy and technology cost matter for participants who support the general mileage user-fee (see second and

[12] In other words, the GPS installation is believed to be less convenient than reporting mileage every year. We acknowledge that these are two different types of inconveniences; *start-up* in the case of GPS and *annual reporting* in the case of the odometer.

third rows of Panel B). We estimate the cost effect by comparing the share of switchers within each GPS mode. The basic GPS mode has 43 percent switchers when the *government pays* and 58 percent switchers when drivers pay. Since the only difference between the *drivers pay* and the *government pays* samples is who pays for the installation, the 15 percentage point difference in the share of switchers can be attributed to the difference in technology cost. The comparable estimate using the advanced GPS mode is five percentage points. Since the only difference between the two GPS modes is the privacy characteristics, this observed 10 percentage point difference in the cost estimate may be attributed to perceived differences in privacy concern.

The privacy effect depends on how it is measured. There is no privacy effect when we compare basic GPS switchers with the advanced GPS switchers in the *driver pays* subsample; the share of switchers is the same in both cases. On the other hand, the privacy effect is estimated at 10 percentage points in the *government pays* subsample; the share of switchers is 43 percent for the basic GPS and 54 percent for the advanced GPS. Participants appear to ignore privacy differences if they have to pay for the device. This conclusion is supported by a more formal parametric model where we reshape the data so that there are two observations per participant (one for basic GPS and one for advanced GPS), and estimate the following model:

$$O_{im} = \alpha + \beta Mode_i + \gamma \cos t_{im} + \delta Mode_i * \cos t_{im} + \lambda order_i + \sigma X_i + \varsigma_{im}, \quad (3)$$

where *Mode* is equal to one if advanced GPS and zero if basic GPS and all other variables are as defined in (1).

We find that people are more likely to switch under an advanced GPS (β = 0.09), which suggests that privacy matters, and more likely to switch if they have to pay (γ = 0.14), which suggests that cost matters. However, the effect of technology cost on advanced GPS switchers is much lower than on basic GPS switchers (δ = -0.08). More importantly, the probability of

switching under an advanced GPS system is no different than the probability of switching under a basic GPS system if users have to pay for the GPS device ($\beta + \delta = 0.01$). These results are not affected by the inclusion of individual characteristics (results available upon request).

Finally, we calculate the privacy effect by comparing odometer switchers with basic and advanced GPS switchers in the subsample where the *government pays* for the GPS device (second row of Panel B of Table 5). This comparison removes the cost effect since there are no start-up costs on vehicle owners. The estimated privacy effect is 23 (=43-20) percentage points and 34 (=54-20) percentage points for the basic and advanced GPS modes, respectively. Although these estimates are net of the cost effect, they are likely biased by other differences such as perceived convenience. Nonetheless, the estimates are probably reasonable upper bounds on the privacy effects.

2. Parametric Method

We extend the count method analysis by estimating a parametric model that allows us to better control for features of the various modes as well as individual socioeconomic characteristics. These results are presented in Table 7.

We find strong evidence that privacy matters for the share of switchers in each mode; estimates are large and statistically different from zero. However, technology cost only seems to matter for the basic GPS mode. In particular, participants who have to pay for the basic GPS device are more like to switch from support to oppose. This finding is consistent with the results presented in Table 5. First, randomization into cost treatment suggests that cost should have no effect on odometer switchers, and this is what we find. Furthermore, the results in Panel A of Table 7 confirm that the 15 percentage point difference in basic GPS switchers reported in Panel

B of Table 5 is statistically different from zero. On the other hand, the five percentage point difference in advanced GPS switchers reported in Table 5 is not statistically different from zero.

Again, we find little to no evidence that individual characteristics matter for the probability of switching. Including these additional covariates does not affect the cost and privacy estimates. These results are available upon request.

V. CONCLUSION AND POLICY IMPLICATIONS

The fuel tax has grown increasingly inadequate as a means of financing road infrastructure at both the federal and state level in the United States due in part to an increase in fuel economy and rising construction costs. One solution is the use of a mileage user-fee, which – in its simplest form – is a charge for each mile of vehicle travel. Although a growing literature is exploring this solution, very little is known about the impact of design features on willingness to support mileage user-fees. We begin to fill this gap in the literature by exploring how opinion is influenced by privacy concerns and technology costs using data drawn from the 2013 IU-SPEA Mileage User-Fee Survey.

We find that although the vast majority of respondents oppose the mileage user-fee regardless of how it is designed, public support can be enhanced by paying careful attention to design features. For example, we find evidence that perceived invasion of privacy and out-of-pocket technology costs to vehicle owners reduce willingness to support a mileage user-fee. The evidence also shows that people who are favorably disposed to the adoption of mileage user-fees are more likely to oppose policy proposals that do not shield them from cost and privacy concerns. Therefore, it is important that mileage user-fee policy proposals minimize direct technology-related out-of-pocket costs on vehicle owners. It is also important that mileage user-

fees be designed such that mileage information receives the highest level of privacy protection. Additionally, steps must be taken to convince the public that these privacy standards will be implemented and enforced.

An alternative approach is to implement mileage user-fees via methods that do not collect location data or methods that do not involve third-party tracking devices. We find that approximately 20 percent of respondents have no privacy concerns related to the ability of GPS devices to track their locations, which suggest that policymakers may also consider offering the public a menu of mileage reporting options that vary in the amount of data they collect. This would allow each vehicle owner to select the method that he prefers. This approach will be implemented in Oregon when their mileage user-fee, a small-scale voluntary approach, officially rolls out in July 2015.

Public opposition to taxation is solidifying, thus making it difficult for public authorities to raise the funds needed to provide public goods such as roads and other infrastructure. Having a clear understanding of how best to design a mileage user-fee – or other revenue sources – will make it easier for policy makers to raise the revenue needed to provide these services. Therefore, future research should examine additional design features that are likely to influence public attitudes toward mileage road user-fees. Such features include the size of the fee, whether it is automatically adjusted each year for changes in construction costs, whether it is adjusted based on vehicle weight, road type, day of the week, time of the day, and degree of traffic. The details of these design features are likely to matter to a significant number of motorists.

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Table 1: Summary statistics of covariates

Variable	Mean	Std. Err.	Variable	Mean	Std. Err.
Age	47.131	0.474	Need for road work		
Male	0.481	0.014	Need	0.330	0.013
Working	0.570	0.013	Some need	0.417	0.013
Head of Household	0.805	0.012	No need	0.253	0.012
Married	0.535	0.014	# of Vehicles owned		
Userfee1	0.341	0.013	No vehicle	0.084	0.009
Race			One vehicle	0.292	0.012
White	0.675	0.014	Two vehicles	0.376	0.013
Black	0.118	0.010	Three vehicles	0.160	0.010
Hispanic	0.137	0.011	More than three vehicles	0.088	0.007
Other	0.070	0.008	Use Interstate		
Region			Once a year	0.146	0.010
Northeast	0.180	0.010	A few times a year	0.174	0.010
Midwest	0.217	0.011	Once every one or two months	0.099	0.008
South	0.367	0.013	A couple of times a month	0.191	0.011
West	0.236	0.012	1 to 3 days per week	0.171	0.010
Party Identification			4 to 5 days per week	0.123	0.009
Republican	0.233	0.011	6 to 7 days per week	0.096	0.008
Moderate	0.413	0.014			
Democrat	0.354	0.013			

Notes: Except for age, covariates are dummy variables. The minimum age is 18 and the maximum is 92. *Userfee1* is a dummy variable that takes a value of one if individual *i* agrees that those who use the road should pay more than those who do not use the road or only those who use the road should pay, and zero otherwise. *Party Identification* is constructed from a 7-point Likert scale where the *Moderate group* includes individuals who '*Lean Republican*', '*Lean Democrat*' or are '*Undecided/Independent/Other*'. Number of observations is 2017.

Table 2: Support for mileage user-fees by mode of administration

Modes	Share who Support	General Mode	Odometer Mode	Basic GPS Mode
General Mode	0.211	-	-	-
	(0.011)	-	-	-
Odometer	0.216	0.005	-	-
	(0.011)	(0.009)	-	-
Basic GPS	0.152	-0.059***	-0.064***	-
	(0.010)	(0.011)	(0.010)	-
Advanced GPS	0.133	-0.078***	-0.083***	-0.019**
	(0.009)	(0.011)	(0.010)	(0.008)
N. Obs.	2077	2077	2077	2077

Notes: Standard errors – clustered on individuals – are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. The first column reports the share of participants who support each mode of the mileage user-fee. Columns 2 to 4 report how support for each mode (indicated in rows) differs from the support for the mode indicated in the respective column titles.

Table 3: Impact of cost and privacy on support for mileage user-fees

	Model 1	Model 2	Model 3	Model 4	Model 5
			Panel A: Basic GPS		
Driver pays	-0.480***	-0.504***	-0.505***	-0.448***	-0.448***
	(0.158)	(0.165)	(0.167)	(0.167)	(0.169)
Order	-0.305*	-0.278*	-0.329**	-0.327*	-0.382**
	(0.158)	(0.163)	(0.166)	(0.167)	(0.170)
Third-party access			-0.625***		-0.690***
			(0.181)		(0.185)
No location tracking				1.529***	1.566***
				(0.240)	(0.245)
Constant	-1.373***	-1.779***	-1.361***	-2.903***	-2.462***
	(0.129)	(0.472)	(0.490)	(0.537)	(0.555)
Log Likelihood	-824.69	-769.51	-761.21	-725.11	-715.57
N. Obs.	2005	2005	2005	2005	2005
			Panel B: Advanced GPS		
Driver pays	-0.399**	-0.463***	-0.427**	-0.456***	-0.426**
	(0.163)	(0.170)	(0.177)	(0.172)	(0.177)
Order	-0.257	-0.222	-0.240	-0.246	-0.239
	(0.163)	(0.169)	(0.175)	(0.171)	(0.175)
Location tracking			-1.363***		-1.378***
			(0.182)		(0.208)
Third-party access				-0.620***	0.038
				(0.193)	(0.229)
Constant	-1.589***	-1.763***	-0.708	-1.414***	-0.717
	(0.133)	(0.479)	(0.521)	(0.503)	(0.522)
Log Likelihood	-760.93	-690.57	-651.96	-683.84	-651.94
N. Obs.	2006	2006	2006	2006	2006
Control Vector	No	Yes	Yes	Yes	Yes

Notes: Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is a dummy that is equal to one if support mileage user-fee and zero if oppose mileage user-fee; type of mileage user-fee is indicated in panel titles. *Order* indicates that participant responded to questions about the basic GPS mode before the advanced GPS mode. *Third-party access* indicates that people outside of government will have easy access to the mileage data. Control vector includes: age, sex, race, employment status, head of household status, region of residence, marital status, party identification, opinion on need for roads, use of interstates, number of vehicles owned and belief in the benefit view principle of taxation. Full specification is reported in Tables A1 and A2 of the appendix.

Table 4: Impact of cost and privacy on support: interaction model

	Panel A: Basic GPS Mode			
	Third-party access		No location tracking	
Driver pays	-0.687**	-0.671**	-0.654	-0.742*
	(0.291)	(0.326)	(0.422)	(0.433)
Order	-0.372**	-0.338**	-0.383**	-0.350**
	(0.159)	(0.163)	(0.161)	(0.164)
Privacy	-0.730***	-0.730***	1.440***	1.398***
	(0.223)	(0.235)	(0.302)	(0.311)
Privacy x Driver pays	0.246	0.254	0.263	0.396
	(0.345)	(0.374)	(0.456)	(0.468)
Constant	-0.784***	-1.085**	-2.414***	-2.551***
	(0.201)	(0.500)	(0.278)	(0.560)
Log Likelihood	-843.50	-782.78	-801.52	-743.02
N. Obs.	2060	2006	2061	2007
	Panel B: Advanced GPS Mode			
	Location tracking		Third-party access	
Driver pays	-0.481*	-0.408	-0.392	-0.396
	(0.288)	(0.316)	(0.267)	(0.283)
Order	-0.269*	-0.270	-0.288*	-0.264
	(0.162)	(0.169)	(0.167)	(0.172)
Privacy	-0.800***	-0.600**	-1.517***	-1.333***
	(0.237)	(0.254)	(0.228)	(0.232)
Privacy x Driver pays	0.089	-0.047	0.013	-0.033
	(0.348)	(0.382)	(0.340)	(0.360)
Constant	-0.955***	-1.152**	-0.499**	-0.431
	(0.213)	(0.512)	(0.200)	(0.520)
Log Likelihood	-783.29	-710.92	-739.83	-678.74
N. Obs.	2064	2006	2064	2006
Control Vector	No	Yes	No	Yes

Notes: Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable is a dummy that is equal to one if support mileage user-fee and zero if oppose the mileage user-fee; type of mileage user-fee is indicated in panel titles. The definition of *privacy* used in each specification is indicated in column titles. *Third-party access* indicates that people outside of government will have easy access to the mileage data. *Order* indicates that participant responded to questions about the basic GPS mode before the advanced GPS mode. Control vector includes: age, sex, race, employment status, head of household status, region of residence, marital status, party identification, opinion on need for roads, use of interstates, number of vehicles owned and belief in the benefit view principle of taxation.

Table 5: Transitions: Count method.

	Odometer			Basic GPS			Advanced GPS		
	Oppose	Support	Total	Oppose	Support	Total	Oppose	Support	Total
Panel A: Oppose General Mode									
Full sample	93.98	6.02	100	94.12	5.88	100	94.95	5.05	100
Gov't pays subsample	-	-	-	92.95	7.05	100	93.61	6.39	100
Driver pays subsample	-	-	-	95.25	4.75	100	96.26	3.74	100
Panel B: Support General Mode									
Full sample	20.26	79.74	100	50.13	49.87	100	55.88	44.12	100
Gov't pays subsample	-	-	-	43.33	56.67	100	53.52	46.48	100
Driver pays subsample	-	-	-	57.73	42.27	100	58.54	41.46	100
Panel C: Total									
Full sample	78.43	21.57	100	84.83	15.17	100	86.73	13.27	100
Gov't pays subsample	-	-	-	81.9	18.1	100	84.68	15.32	100
Driver pays subsample	-	-	-	87.76	12.24	100	88.79	11.21	100

Notes: Reported is the percent of participants who oppose or support each mode of mileage user-fee, conditional on whether they oppose the *general* mode (Panel A) or support the *general* mode (Panel B). Panel C reports unconditional level of support for each mode. Number of observations is 2077, 2074 and 2073 for odometer, basic GPS and advanced GPS, respectively. Since everyone responded to the same odometer mode question, the response of participants in the *driver pays* and *government pays* samples is the same as in the full sample.

Table 6: Support for arguments for and against mileage user-Fee

Characteristics	Support General Mode		Oppose General Mode	
	Agree	Disagree	Agree	Disagree
	Odometer Mode			
Q17A: Invasion of privacy	0.398	0.602	0.765	0.235
Q17B: Inconvenient to report mileage	0.471	0.529	0.756	0.244
Q17C: People will report mileage honestly	0.605	0.395	0.359	0.641
Q17D: People will tamper with odometer	0.561	0.440	0.649	0.351
Q17E: Audit will keep people honest	0.625	0.375	0.365	0.635
Q17F: Easy to administer	0.792	0.208	0.474	0.526
	Basic GPS Mode			
Q26A: Records mileage accurately	0.783	0.217	0.574	0.427
Q26B: Hard to tamper with	0.552	0.448	0.391	0.609
Q26C: People will tamper with GPS	0.575	0.425	0.684	0.316
Q26D: Inconvenient to get GPS installed	0.630	0.370	0.784	0.216
Q26E: Easy for third party to access data	0.722	0.278	0.810	0.190
Q26F: Like that government only monitors number of miles	0.814	0.186	0.570	0.430
Q26G: Waste money to buy GPS; cars already have odometer	0.642	0.358	0.794	0.206
Q26I: $250 is too much for the GPS device	0.824	0.176	0.884	0.116
Q26J: Audit will keep people honest	0.651	0.349	0.393	0.607
	Advanced GPS Mode			
Q34A: Like that congestion pricing possible	0.519	0.481	0.172	0.828
Q34B: Like that state specific pricing possible	0.622	0.378	0.185	0.815
Q34C: Don't like government monitoring location and time data	0.662	0.338	0.842	0.158
Q34D: Easy for third party to access data	0.747	0.253	0.832	0.168
Q34E: Location data will have a lot of errors	0.761	0.239	0.857	0.143
Q34F: Audit will keep people honest	0.621	0.379	0.380	0.620
Q34H: $250 is too much for the GPS device	0.812	0.188	0.880	0.120
Q34I: Like that I can monitor people driving my cars	0.349	0.651	0.163	0.837
N. Obs.	447		1588	

Notes: Reported is the share of participants who agree or disagree with various statements about each mode of administering a mileage user-fee, conditional on whether they support the general mileage user-fee (columns 1 and 2) or oppose the general mileage user-fee (columns 3 and 4). The complete text used for each statement is reported in the appendix and unconditional responses to each statement are available upon request. Statements Q26H and Q34G are omitted because, by design, only one half of the panel saw each statement.

Table 7: Impact of cost and privacy on probability of switching

	Model 1	Model 2	Model 3	Model 4	Model 5
			Panel A: Basic GPS		
Driver pays	0.636***	0.563**	0.579**	0.499**	0.505**
	(0.241)	(0.247)	(0.250)	(0.253)	(0.256)
Order	0.376	0.448*	0.508*	0.479*	0.557**
	(0.241)	(0.256)	(0.260)	(0.260)	(0.262)
Third-party access			0.582**		0.681**
			(0.289)		(0.300)
No location tracking				-1.555***	-1.619***
				(0.336)	(0.355)
Constant	-0.476**	-0.070	-0.365	0.886	0.595
	(0.216)	(0.812)	(0.827)	(0.843)	(0.839)
Log Likelihood	-279.87	-254.86	-252.28	-241.73	-238.50
N. Obs.	443	443	443	443	443
			Panel B: Advanced GPS		
Driver pays	0.298	0.386	0.422*	0.393	0.422
	(0.238)	(0.245)	(0.256)	(0.248)	(0.257)
Order	0.289	0.470*	0.444*	0.495*	0.456*
	(0.238)	(0.254)	(0.261)	(0.258)	(0.262)
Location tracking			1.140***		1.071***
			(0.290)		(0.305)
Third-party access				0.595*	0.241
				(0.304)	(0.330)
Constant	-0.055	-0.303	-1.025	-0.644	-1.123
	(0.208)	(0.840)	(0.938)	(0.899)	(0.976)
Log Likelihood	-281.34	-249.82	-239.26	-247.30	-238.91
N. Obs.	442	442	442	442	442
Control Vector	No	Yes	Yes	Yes	Yes

Notes: Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. Dependent variable in Panel A is a dummy that is equal to one if oppose the basic GPS-based mileage user-fee conditional on supporting the general mileage user-fee and zero if support the basic GPS-based mileage user-fee conditional on supporting the general mileage user-fee. Dependent variable in Panel B is defined similarly for the advanced GPS-based mileage user-fee. *Third-party access* indicates that people outside of government will have easy access to the mileage data. *Order* indicates that participant responded to questions about the basic GPS mode before the advanced GPS mode. Control vector includes: age, sex, race, employment status, head of household status, region of residence, marital status, party identification, opinion on need for roads, use of interstates, number of vehicles owned and belief in the benefit view principle of taxation. Full specification is reported in Table A2 in the appendix.

VII. APPENDIX: QUESTIONNAIRE DETAILS

Statements about *General* mileage user-fee: Q14

A. A mileage user-fee makes it easy for road users to calculate how much they pay the government for using the roads.
B. A mileage user-fee is an accurate way to charge road users for the wear and tear they cause on the roads.
C. A mileage user-fee is unfair to people living in rural areas because they have to drive more miles to get to places they need to go.
D. A mileage user-fee is unfair to people who drive a lot on the job (for example, truckers, sales people, and taxi drivers).
E. Collecting information about a person's mileage is an invasion of privacy, unless the collection is voluntary.
F. A mileage user-fee is unfair to people who drive fuel efficient vehicles.

Statements about Odometer mileage user-fee: Q17

A. Reporting odometer mileage to the government is an invasion of privacy.
B. Reporting my odometer mileage to the DMV each year will be inconvenient.
C. Most people will honestly report the mileage on the odometer in their cars.
D. A significant number of motorists will tamper with the odometer in their car.
E. The audit process will keep most people from tampering with the odometer in their cars.
F. The odometer mileage user-fee would be easy to implement since every vehicle already has an odometer.

Statements about Basic GPS mileage user-fee: Q26

A. GPS systems are accurate in measuring miles of travel.
B. It is difficult to tamper with a GPS system.
C. Many drivers would tamper with their GPS systems if the government relies on GPS to collect mileage data for the mileage user-fee.
D. It would be inconvenient to have to get the GPS device installed in my car.
E. It would be easy for someone outside of the government to get access to my GPS mileage data.
F. I like that this simple GPS system only tracks the total number of miles driven, so the government **cannot** monitor when and where I drive.
G. It is a waste of money to buy those GPS devices since all cars already have an odometer.
H. I dislike this simple GPS-based mileage user-fee because I have to pay for the GPS device.
I. $250 is too much to pay for the GPS device.
J. The audit process will keep most people from tampering with the GPS system or the odometer in their cars.

Statements about Advanced GPS mileage user-fee: Q34

A. I like this advanced GPS system because a higher rate could be charged for driving on congested roads.
B. I like this advanced GPS system because the government in each state could charge and collect taxes from every driver who drives in that state (including drivers from other states).
C. I don't like this advanced GPS system because the government will be able to monitor when and where I drive.
D. It would be easy for someone outside of the government to get access to my GPS mileage data.

E. There are likely to be a lot of errors in trying to use location data to charge different fees.
F. The audit process will keep most people from tampering with the GPS system or the odometer in their cars.
G. I dislike this advanced GPS-based mileage user-fee because I have to pay for the GPS device.
H. $250 is too much to pay for the GPS device.
I. I like the advanced GPS-based mileage user-fee because it would allow me to monitor people who drive my cars.

Table A1: Impact of cost and privacy on support for Basic GPS-based mileage user-fees

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Driver pays	-0.480***	-0.504***	-0.505***	-0.448***	-0.448***
	(0.158)	(0.165)	(0.167)	(0.167)	(0.169)
Order	-0.305*	-0.278*	-0.329**	-0.327*	-0.382**
	(0.158)	(0.163)	(0.166)	(0.167)	(0.170)
Age		0.007	0.007	0.007	0.007
		(0.006)	(0.006)	(0.006)	(0.006)
Sex (=1 if Male)		0.020	0.018	-0.035	-0.038
		(0.164)	(0.168)	(0.168)	(0.172)
Race (White omitted)					
Black (dummy)		0.249	0.206	0.346	0.322
		(0.273)	(0.280)	(0.277)	(0.279)
Hispanic (dummy)		0.075	0.057	0.109	0.103
		(0.267)	(0.270)	(0.281)	(0.283)
Other (dummy)		0.798**	0.821**	0.727**	0.751**
		(0.315)	(0.321)	(0.326)	(0.335)
Working (dummy)		-0.129	-0.122	-0.091	-0.079
		(0.187)	(0.192)	(0.194)	(0.199)
Head of Household (dummy)		0.087	0.112	0.065	0.080
		(0.253)	(0.258)	(0.256)	(0.262)
Region (Northeast omitted)					
Midwest		0.050	0.033	0.113	0.114
		(0.261)	(0.263)	(0.267)	(0.270)
South		0.267	0.263	0.325	0.340
		(0.221)	(0.222)	(0.235)	(0.239)
West		0.143	0.118	0.172	0.158
		(0.264)	(0.270)	(0.279)	(0.288)
Married (dummy)		-0.021	-0.012	0.011	0.025
		(0.190)	(0.195)	(0.197)	(0.202)
Party affiliation (Republican omitted)					
Moderate		0.252	0.279	0.410*	0.464**
		(0.210)	(0.209)	(0.215)	(0.214)
Democrat		0.402*	0.409*	0.388*	0.409*
		(0.217)	(0.215)	(0.222)	(0.221)
Need for road work ("Need" omitted)					
Some need		-0.213	-0.210	-0.273	-0.271
		(0.186)	(0.188)	(0.192)	(0.196)
No need		-0.513**	-0.467**	-0.569***	-0.519**
		(0.221)	(0.224)	(0.221)	(0.223)

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# of Vehicles (no vehicle omitted)					
One vehicle		-0.202	-0.229	-0.238	-0.289
		(0.361)	(0.370)	(0.362)	(0.368)
Two vehicles		-0.472	-0.463	-0.569	-0.597
		(0.384)	(0.394)	(0.383)	(0.390)
Three vehicles		-0.311	-0.278	-0.446	-0.452
		(0.404)	(0.412)	(0.406)	(0.410)
More than three vehicles		-1.024**	-1.014**	-1.085**	-1.111**
		(0.481)	(0.486)	(0.492)	(0.497)
Use Interstate (less than once a year omitted)					
A few times a year		-0.104	-0.056	-0.141	-0.077
		(0.295)	(0.300)	(0.299)	(0.303)
About once every one or two months		-0.403	-0.438	-0.427	-0.476
		(0.363)	(0.364)	(0.380)	(0.388)
A couple of times a month but not every week		-0.213	-0.160	-0.209	-0.147
		(0.319)	(0.325)	(0.314)	(0.319)
1 to 3 days per week		-0.431	-0.377	-0.453	-0.387
		(0.336)	(0.344)	(0.342)	(0.347)
4 to 5 days per week		-0.291	-0.266	-0.298	-0.255
		(0.337)	(0.344)	(0.339)	(0.344)
6 to 7 days per week		-0.537	-0.508	-0.560	-0.536
		(0.410)	(0.411)	(0.398)	(0.399)
Userfee1		0.896***	0.901***	0.831***	0.830***
		(0.165)	(0.168)	(0.170)	(0.172)
Third-party access			-0.625***		-0.690***
			(0.181)		(0.185)
No location tracking				1.529***	1.566***
				(0.240)	(0.245)
Constant	-1.373***	-1.779***	-1.361***	-2.903***	-2.462***
	(0.129)	(0.472)	(0.490)	(0.537)	(0.555)
Log Likelihood	-824.69	-769.51	-761.21	-725.11	-715.57
N. Obs.	2005	2005	2005	2005	2005

Notes: Dependent variable is a dummy that is equal to one if support basic GPS-based mileage user-fee and 0 if oppose the mileage user-fee. Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. *Order* indicates that participant responded to questions about the basic GPS mode before the advanced GPS mode. *Userfee1* is a dummy variable that takes on a value of one if individual *i* agrees that those who use the road should pay more than those who do not use the road or only those who use the road should pay, and zero otherwise.

Table A2: Impact of cost and privacy on support for Advanced GPS-based mileage user-fees

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Driver pays	-0.399**	-0.463***	-0.427**	-0.456***	-0.426**
	(0.163)	(0.170)	(0.177)	(0.172)	(0.177)
Order	-0.257	-0.222	-0.240	-0.246	-0.239
	(0.163)	(0.169)	(0.175)	(0.171)	(0.175)
Age		0.007	0.006	0.008	0.006
		(0.006)	(0.006)	(0.006)	(0.006)
Sex (=1 if Male)		-0.062	-0.039	-0.076	-0.038
		(0.172)	(0.181)	(0.176)	(0.181)
Race (White omitted)					
Black (dummy)		0.410	0.180	0.352	0.181
		(0.293)	(0.325)	(0.305)	(0.326)
Hispanic (dummy)		0.136	0.099	0.168	0.097
		(0.274)	(0.288)	(0.276)	(0.287)
Other (dummy)		0.597*	0.519*	0.667**	0.513*
		(0.333)	(0.312)	(0.334)	(0.310)
Working (dummy)		-0.291	-0.276	-0.282	-0.276
		(0.203)	(0.203)	(0.206)	(0.203)
Head of Household (dummy)		-0.030	0.016	-0.019	0.016
		(0.266)	(0.286)	(0.273)	(0.285)
Region (Northeast omitted)					
Midwest		-0.294	-0.312	-0.292	-0.313
		(0.276)	(0.274)	(0.278)	(0.274)
South		0.345	0.333	0.344	0.333
		(0.228)	(0.225)	(0.230)	(0.225)
West		0.195	0.097	0.210	0.095
		(0.273)	(0.268)	(0.275)	(0.267)
Married (dummy)		-0.089	-0.105	-0.078	-0.106
		(0.217)	(0.214)	(0.219)	(0.214)
Party affiliation (Republican omitted)					
Moderate		0.133	0.136	0.151	0.134
		(0.227)	(0.233)	(0.227)	(0.233)
Democrat		0.292	0.271	0.290	0.270
		(0.228)	(0.236)	(0.226)	(0.236)
Need for road work ("Need" omitted)					
Some need		-0.285	-0.225	-0.254	-0.226
		(0.194)	(0.196)	(0.196)	(0.197)
No need		-0.712***	-0.662***	-0.660***	-0.665***
		(0.246)	(0.254)	(0.248)	(0.255)

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# of Vehicles (no vehicle omitted)					
One vehicle		-0.017	-0.101	-0.005	-0.103
		(0.329)	(0.350)	(0.343)	(0.350)
Two vehicles		-0.026	-0.062	0.017	-0.065
		(0.369)	(0.387)	(0.384)	(0.387)
Three vehicles		-0.202	-0.247	-0.138	-0.252
		(0.399)	(0.415)	(0.411)	(0.417)
More than three vehicles		-0.394	-0.460	-0.330	-0.467
		(0.455)	(0.502)	(0.471)	(0.505)
Use Interstate (less than once a year omitted)					
A few times a year		-0.154	-0.163	-0.114	-0.166
		(0.270)	(0.295)	(0.276)	(0.295)
Once every one or two months		-0.613*	-0.638*	-0.626*	-0.639*
		(0.351)	(0.363)	(0.358)	(0.363)
A couple of times a month but not every week		-0.516*	-0.450	-0.481*	-0.453
		(0.284)	(0.300)	(0.287)	(0.301)
1 to 3 days per week		-0.621*	-0.570	-0.552*	-0.574
		(0.325)	(0.350)	(0.329)	(0.351)
4 to 5 days per week		-0.634*	-0.523	-0.581	-0.525
		(0.363)	(0.386)	(0.367)	(0.387)
6 to 7 days per week		-1.231***	-1.177***	-1.182***	-1.179***
		(0.407)	(0.421)	(0.408)	(0.422)
Userfee1		1.060***	1.086***	1.062***	1.086***
		(0.172)	(0.179)	(0.175)	(0.179)
Location tracking			-1.363***		-1.378***
			(0.182)		(0.208)
Third-party access				-0.620***	0.038
				(0.193)	(0.229)
Constant	-1.589***	-1.763***	-0.708	-1.414***	-0.717
	(0.133)	(0.479)	(0.521)	(0.503)	(0.522)
Log Likelihood	-760.93	-690.57	-651.96	-683.84	-651.94
N. Obs.	2006	2006	2006	2006	2006

Notes: Dependent variable is a dummy that is equal to one if support advanced GPS-based mileage user-fee and 0 if oppose the mileage user-fee. Robust standard errors are in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%. *Order* indicates that participant responded to questions about the basic GPS mode before the advanced GPS mode. *Userfee1* is a dummy variable that takes on a value of one if individual *i* agrees that those who use the road should pay more than those who do not use the road or only those who use the road should pay, and zero otherwise.