Acceptability of congestion pricing: An experimental investigation[1]

Nicholas Janusch[2], Stephan Kroll, Christopher Goemans, Todd Cherry, Steffen Kallbekken

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Congestion pricing is argued to improve efficiency by reducing travel times and emissions through allocating travel to the highest-valued use. Its implementation, however, is often hindered by equity concerns and debates on how to recycle revenues as well as the ex ante uncertainties of incidences of gains and losses from a lack of any experience with the policy. This paper employs laboratory experiments with heterogeneous users to investigate the effectiveness and acceptability of a toll in a six-player-two-route congestion game. The experiment follows a 2×2 design that varies two treatments: the rate of revenue reallocation and the level of information before the final vote. To measure acceptability and how it is affected by experience with the toll, we conduct referenda before, during, and after subjects experience a congestion problem and a toll. Congestion pricing is found to curb congestion effectively, and although some subjects do not vote in their monetary self-interest initially, the majority does so after experiencing the congestion pricing policy. Data on worldviews and beliefs are collected and matched to voting behavior to examine the evolution of how experience determines acceptability. Some worldviews and beliefs can predict voting behavior and the timing of when an individual finds a toll (un)acceptable.

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[2] Corresponding author.
E-mail addresses: njanusch@udel.edu (N. Janusch), stephan.kroll@colostate.edu (S. Kroll), chris.goemans@colostate.edu (C. Goemans).

1 Introduction

Congestion of any sort, such as the overload of a data network or a queue resulting from a bottleneck of a busy shipping canal is a major problem because it reduces the quality of the service and generates external costs. Traffic congestion, in particular, has been a growing problem. According to the 2012 Urban Mobility Report [Schrank et~al., 2012], 5.9 billion hours were lost in 2011 from the additional travel time from congestion in the United States and 2.9 billion gallons of fuel were wasted. The report estimates average annual costs of congestion in 2011 to be $818 per United States commuter compared to an inflated-adjusted cost of $342 in 1982.[3]

By optimizing road use and making people pay the true cost of their traveling, congestion pricing is argued to be an efficient tool to tackle the congestion problem and lessen its costs. Moreover, most economists agree that revenue-neutral congestion charges "would make citizens on average better off."[4] Examples of congestion-pricing-like policies used in practice include cordon zone pricing of a central business district, variable pricing (or peak pricing) of toll roads, variable pricing of express lanes and high occupancy toll (HOT) lanes, and responsive pricing to manage parking demand. Theoretical models demonstrating the potential impact of congestion pricing on efficient road use date back to [Pigou, 1920], and since then the welfare impacts and incidence of pricing policies have been studied extensively [Small and Verhoef, 2007]. Set at the correct level, the congestion price equals the marginal external congestion cost a traveler creates so that all trips made provide benefits as least as great as their social costs [Small and Verhoef, 2007].[5]

While congestion pricing works in theory, and despite the different kinds of it listed above, there have been relatively few applications [Mahendra et~al., 2012]. Urban congestion pricing has been successfully implemented and accepted in Stockholm, London, Singapore, and Milan, but implementation has failed in places such as Hong Kong, Edinburgh, Manchester, San Francisco, and Manhattan [Ison and Rye, 2005, Anas and Lindsey, 2011]. The congestion pricing literature argues that the lack of acceptability prevails as the main barrier to implementation. Based on the model by [Fernandez and Rodrik, 1991] who explain that governments often fail to adopt efficiency-enhancing policies because of uncertainty and a bias towards the status quo, [De~Borger and Proost, 2012] provide a model on how the presence of uncertainty is responsible for the evolution of public attitudes in places where congestion pricing was introduced like Stockholm and London. Using a simple majority voting model that employs two types of uncertainty (the idiosyncratic individual uncertainty about the exact cost of car use and the political uncertainty on the use of collected revenues), they demonstrate that because of individual uncertainty, a majority of drivers that are ex ante against road pricing may ex post be in favor after a policy trial removes individual uncertainty. The authors argue that this ex post majority favorability may explain why policymakers implement experimental trials against the

[3] Time-delay costs are found to be the largest external costs from congestion when compared to other external costs borne by users and non-users of vehicle travel [Small and Verhoef, 2007].

[4] Congestion Pricing. January 11, 2012. The Initiative on Global Markets. Chicago Booth School of Business. [http://www.igmchicago.org/igm-economic-experts-panel/poll-resultsSurveyID=SV_3aeMp7lK74rrVFa]http://www.igmchicago.org/igm-economic-experts-panel/poll-results?SurveyID=SV_3aeMp7lK74rrVFa. Accessed August 2, 2016.

[5] However, even [Pigou, 1937] recognized that the practical difficulty of determining the correct tax or congestion price would be "extraordinarily great. The data necessary for scientific decision are almost wholly lacking" (p. 42).

political will of the majority of their constituents.

However, acceptability may go beyond self-interest and fairness concerns. Peoples' worldviews and beliefs, as well as psychological responses towards the introduction of congestion pricing, may explain acceptability [Schade and Baum, 2007]. [Kahan et~al., 2011, Kahan et~al., 2012] investigate cultural cognition of risks and hypothesize that peoples' opinions on risks are derived from the values of groups they associate with rather than just their scientific understanding of the issue. They examine how cultural cognition shapes individuals beliefs about the existence of scientific consensus relating to climate change, the disposal of nuclear waste, and the effect of permitting concealed possession of handguns. In [Kahan et~al., 2012], cultural worldviews explain more of the variance of perceived risks of climate change than scientific literacy and numeracy, and that polarization of the perceived risks increases between cultural worldviews as scientific literacy and numeracy increases. Concerning the acceptability of congestion pricing, opinions may be formed beyond self-interest and the policy's individual welfare effects.

Understanding why congestion pricing was accepted in some places but not in others by observing both the performance and acceptability of congestion pricing at an individual level in the real world would be ideal. But such data collection would be too costly and almost impossible to implement. Alternatively, we turn to experimental economics. [Falk and Heckman, 2009] argue that laboratory experiments complement other empirical methods and data sources in the social sciences. Laboratory experiments allow for a low financial and political cost alternative. They provide a controlled environment in which researchers can test competing theories or evaluate the impacts of alternative policies on participant behavior.

Previous laboratory experiments in the transportation economics literature have examined travel decisions (e.g., departure time, route choice, or mode choice) and how congestion pricing, information disclosure, and a new link in a transportation system affect user travel behavior [Seale et~al., 2005, Hartman, 2007, Ziegelmeyer et~al., 2008, Selten et~al., 2007, Anderson et~al., 2008, Denant-Boemont and Hammiche, 2009, Morgan et~al., 2009, Hartman, 2012, Dechenaux et~al., 2014]. To our knowledge, no laboratory congestion experiments of incorporate voting or measures of public acceptability. The most relevant laboratory congestion experiments on congestion pricing use two-route networks to investigate the Pigou-Knight-Downs paradox, which states that improvements in a road network might not improve traffic congestion. [Anderson et~al., 2008] and [Hartman, 2012] investigate the effects of an efficient toll and information disclosure of past entrants and do find similar results regarding the effect of information and that the toll has its intended effects. [Hartman, 2006, Hartman, 2007] also examines travel behavior when individuals have either *real* or assigned heterogeneous time preferences; [Hartman, 2007] compares the outcomes from the same toll when heterogeneous users have different assigned value-of-time distributions (no, low, or high heterogeneity). However, the outcomes were not compared to the behavior of the same assigned heterogeneous individuals for when no toll existed in the network. Our experiment is the first to compare route-choice behavior with and without a toll of heterogeneous individuals with assigned values of time.

Recent experimental papers on public acceptability of Pigouvian policies have examined factors that contribute to the (un)acceptability of Pigouvian policies. [Cherry et~al., 2014] find that experience of a trial run of a Pigouvian tax increases the acceptability of the tax and that the positive experience can overcome misperception and biases.[6] [Kallbekken et~al., 2011] observe that a lack of understanding of the workings and effects of a Pigouvian tax instrument does not influence the opposition of such policies. The authors also find an aversion to Pigouvian taxes– opposition to taxes that can increase individual and social welfare. By challenging the behavioral notion that people act solely on their monetary self-interes, this result reveals a barrier in implementing potentially efficient policies. Our research contributes by examining personal attributes that may affect acceptability as well as have a context where a policy either creates all 'winners' or both 'winners' and 'losers' with unequal outcomes.

This paper investigates how the effectiveness and personal experience of a policy trial, and an individual's worldviews and beliefs influence the acceptability of congestion pricing. The paper addresses three questions: First, does congestion pricing (a toll on a congestible route) work in the lab? Second, does experience and the resulting removal of the policy's uncertainties from a policy trial influence acceptability? Third, do individual attributes determine the acceptability of tolls and does this acceptability evolve when an individual becomes accustomed to the problem and policy?

We employ a two-route congestion game. Groups of six individuals with heterogeneous time preferences choose between two routes where one route is shorter but congestible, and the other route has a longer but constant travel time. Groups experience the game without and with tolls, and subjects vote in referenda at three different times in the experiment on whether the last stage of the experiment should have a toll. The votes provide a measure of the evolution of the acceptability of the toll by first obtaining an initial stated preference of tolls given exogenous characteristics, and then any changes in attitudes from being accustomed to the congestion problem and the congestion pricing policy.

This study utilizes a 2×2 treatment experiment to address the research questions. Different expected welfare effects from the toll are varied based on how much toll revenue is redistributed lump-sum: individuals should either all be better off by varying amounts (100% revenue redistribution), or some individuals are made better or worse off by varying amounts (40% revenue redistribution). The other variation of treatments intends to answer the last two research questions on voting behavior by investigating an individual's reaction if they observe the welfare effects and inequities from the toll of all members of their group. One treatment provides, before the third vote, information on the individual's average total costs between the first two rounds and how much their costs change from the toll. The alternative treatment discloses the same performance information for the individual but also discloses ranked performance information of all six members in the group. Individuals might react and vote differently and not solely in their monetary self-interest if they see that the policy creates inequities.

At the end of the experiment, we conduct a survey that gauges an individual's cultural worldviews [Kahan et~al., 2011], altruism, and views of the environment [Kotchen and Moore, 2007], their political ideology, as well as other demographic information. These responses are matched with an individual's voting behavior to investigate whether they predict an individual's evolution of acceptability of congestion pricing. This paper contributes to the

[6] This finding is consistent with survey responses reported in [Swanson and Hampton, 2013] who observed that focus group participants changed their attitudes towards congestion pricing significantly after receiving information on congestion problems, the purpose of congestion pricing and the states of transportation funding.

literature by providing insights of voting behavior and the presence of a bias towards the status quo that would be difficult or nearly impossible to collect in the field. It does this by being the first to test in a laboratory environment the effect of a toll on congestion performance of heterogeneous users (compared to a no-toll policy), and through an experimental design that allows for observing the evolution of acceptability of congestion pricing using incentive-compatible votes.

The results show that overall the tolling policy achieves the objective of reducing congestion and increasing societal welfare. No pattern of subjects voting based on their monetary self-interest for the first vote is observed. Being accustomed to the congestion problem and the toll impacts the acceptability of a toll, and ex post monetary self-interest, unsurprisingly, appears to be a major determinant since the trial removes the uncertainty surrounding the toll's individual effects (providing measures of the toll's effects on their costs makes the removal of uncertainty even more definitive). Surprisingly, even after the policy trial, some individuals did not vote in their own monetary self-interest. Lastly, personal attributes and beliefs are not a major determinant on initial feelings of congestion pricing; however, these attributes became significant after everyone became accustomed to the congestion problem.

The following sections provide an explanation of the theoretical two-route congestion model used in the experiment (Section 2) and the design of the experiment (Section 3). Section 4 discusses the empirical results, and the paper concludes with Section 5.

2 Theoretical model

We employ a two-route congestion model where N heterogeneous individuals have the option of taking one of two routes (A or B) to get them to their destination (similar models have been developed by, for example, Arnott et al., [arnott1994welfare]). The total cost incurred by each individual, i, to reach their destination is a function of the amount of time spent en route and their value of time. Total travel time for Route B is equal to d. Alternatively, Route A is assumed congestible. Total time traveling on route A is a function of the number of users who take Route A and equals $a + b \times \sum_i x_i$, where x_i equals to one if i takes Route A and zero otherwise, and a and b are exogenous parameters.

The per-unit cost of time, c_i, varies across individuals. Each of the N possible entrants are indexed based on their relative value of time so that $c_i > c_{i+1} \quad \forall \quad i \in (1, \ldots, N-1)$.

The socially optimal distribution of travelers across Routes A and B is obtained by solving the following problem:

$$\operatorname*{Min}_x \quad \sum_i x_i c_i \left[\left(a + b \times \sum_i x_i \right) \right] + \sum_i (1 - x_i) c_i d \tag{1}$$

Note that in the case where c_i is equal across all users, this problem is the equivalent of the travel time minimization problems used by [Selten et~al., 2007], [Anderson et~al., 2008], and [Hartman, 2012]. However, unlike those setups, the solution to this problem follows [Hartman, 2007] by identifying not only the optimal number of Route A travelers but also which travelers should take the congestible route.

The solution to this problem is characterized by the following set of entrance rules that all hold at the social optimum:

$$x_1^{sp} = \begin{cases} 1, & c_1\left(d-\left(a+b\left(\sum_{j\neq 1} x_j+1\right)\right)\right) \geq \sum_{j\neq 1} x_j c_j b \\ 0, & otherwise \end{cases}$$
$$\vdots$$
$$x_i^{sp} = \begin{cases} 1, & c_i\left(d-\left(a+b\left(\sum_{j\neq i} x_j+1\right)\right)\right) \geq \sum_{j\neq i} x_j c_j b \\ 0, & otherwise \end{cases}$$
$$\vdots$$
$$x_N^{sp} = \begin{cases} 1, & c_N\left(d-\left(a+b\left(\sum_{j\neq N} x_j+1\right)\right)\right) \geq \sum_{j\neq N} x_j c_j b \\ 0, & otherwise \end{cases} \tag{2}$$

The left-hand side of each inequality above represents the benefit to individual i of taking Route A relative to Route B; whereas the right-hand side represents their impact on other players. The above condition simply states that the optimal distribution of travelers is one in which for all individuals entering Route A the benefit exceeds the cost imposed on other travelers, and for all who take Route B the opposite is true.

In contrast, each individual i solves the following cost-minimization problem that does not take the congestion costs of others into account:

$$\underset{x_i}{\text{Min}} \quad x_i c_i\left(a+b\sum_j x_j\right)+(1-x_i)c_i d \tag{3}$$

The solution to the individual's problem, denoted x_j^*, is defined by:

$$x_i^*(x_{-i}) = \begin{cases} 1, & c_i\left(d-\left(a+b\left(\sum_{j\neq i} x_j+1\right)\right)\right) \geq 0 \\ 0, & otherwise \end{cases} \tag{4}$$

The condition identifying each individual's optimal route choice differs from that of the social planner's by $\sum_{j\neq i} x_j c_i b$, the cost imposed on other travelers when individual j enters Route A. As long as one person enters Route A then an external cost exists and is shared across all Route A users, $\sum_{j\neq i} x_j c_i b > 0$, which can lead to a potentially inefficient distribution of travelers across the two routes.

Congestion pricing involves the introduction of a toll, τ, into each individual's optimization problem that reflects their impact on other users at the social optimum. Let $\tilde{i}^{sp}$ denote the marginal traveler for which it is socially optimal to enter Route A, then the following identifies the set of tolls that will result in the efficient use of Routes A and B:

$$c_{\tilde{i}^{sp}+1}\left(d-\left(a+b\left(\sum_{i<\tilde{i}^{sp}+1} x_i+1\right)\right)\right)<\tau \leq c_{\tilde{i}^{sp}}\left(d-\left(a+b\left(\sum_{i<\tilde{i}^{sp}} x_i+1\right)\right)\right) \tag{5}$$

As will be discussed below, the efficient time-minimizing outcome may not be efficient according to the social planner's objective of minimizing total travel costs. Furthermore, individuals may discount the posted value of the toll by compensating for the rate and method of revenue redistribution. Such discounting may affect incentives and undermine the social planner's objective and effectiveness of the toll.

The experiment uses $N=6$, $a=4$, $b=1$, $d=12$ as the parameters of the congestion game.[7] These parameters create the possible travel time outcomes displayed in Table 1. Note that no user will have the incentive to enter Route B without a toll. The six individuals are split into users with high values of time (12, 11, and 10 tokens per minute) and users with low values of time (4, 3, and 2 tokens per minute). These values of times, the congestion toll, and redistribution rates are selected for the intended welfare effects, and the existence and uniqueness of pure strategy Nash equilibria both with and without the toll.

Figure 1 illustrates the two-route problem by showing the marginal benefit and marginal costs for each Route A entrant for heterogeneous users with values of times of 12, 11, 10, 4, 3, and 2 in descending order. Notice the time externality–the marginal social cost–increases for each additional user entering Route A. The externality that is imposed on users currently taking Route A is reflected by the decline in the marginal benefit function. Users do not internalize this externality. Therefore all six users will use Route A since they will gain positive marginal private benefits. However, to incentivize users in the system to make socially optimal decisions, a toll should be 50 $\geq toll >$ 16, ignoring any cost adjustments users may make from revenue redistribution.[8]

Consider the intuition for the possible travel outcomes detailed in Table 1. Without a toll, Route B is always inferior to Route A and all six users will use Route A creating a total travel time of 10 minutes for each of the six users, or 60 total minutes. If the objective were to minimize total travel time (and travel costs if $c(i)$ is equal across users), then the theoretical outcome is for four entrants, or for four people to use Route A and two to go Route B (56 total minutes). However, with the experiment's given values of time for the six participants and Equation ??, the optimal travel-cost-minimizing level is for the three high-value users to use Route A and the three low-value users to use Route B. The Nash equilibrium outcome (usually referred to as the "user equilibrium" in the transport literature) occurs when no user can improve their situation through unilateral action. The predicted user equilibrium here yields a total social travel time cost of 420 tokens, while the cost at the social optimum, where travel costs are minimized, is 339 tokens (57

[7] Having $N<x^*$ ensures a toll impacts welfare before revenue redistribution and for all users to understand the congestion problem if one player deviates from their dominated strategy. The predicted pure strategy Nash equilibrium if $N>8$ is for eight users to enter Route A; however, a Nash equilibrium exists in mixed strategies. By having $N<8$ ensures a unique pure strategy Nash equilibrium and should allow all individuals have the same experience without a toll.

[8] See [Hartman, 2012] for a theoretical derivation of marginal external costs in a similar framework.

total minutes) at the optimum. The user equilibrium without any intervention increases system costs by 23.9 percent.

Table 1: Possible travel time outcomes (N =6, a =4, b =1, and d =12)

	Total Travel Time (in minutes)	
Number of people using Route A	Route A	Route B
1	5	12
2	6	12
3	7	12
4	8	12
5	9	12
6	10	12

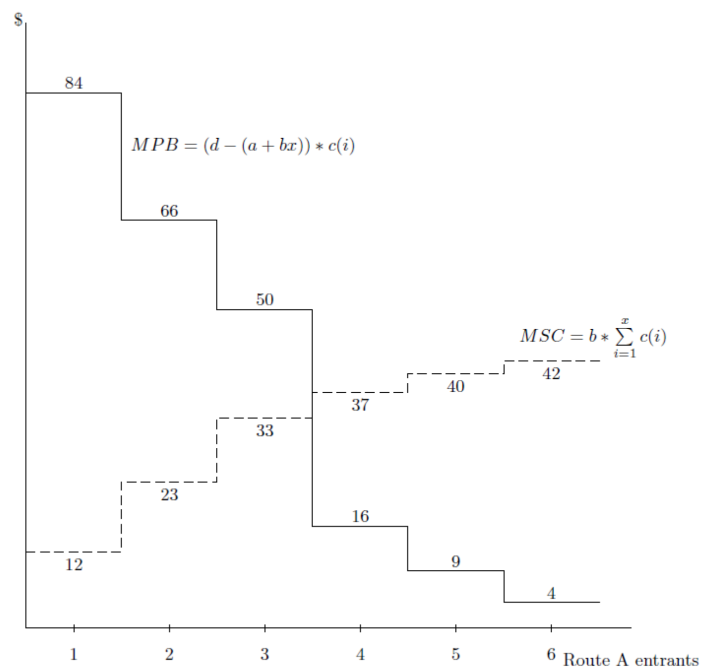


Figure 1: Graphical Representation of MPB and MSC

In this two-route network with heterogeneous users, an efficient toll reduces total group costs but makes some users worse off. The level of the toll and type of revenue redistribution can compensate some or all of the low-value-of-time users' losses from taking the longer route, Route B. As described in the next section, we chose a 21-token toll and manipulated the level of lump-sum redistribution (100% or 40%) to obtain the desired welfare effects for addressing the objectives of this study. Note that even without any revenue redistribution, the travel cost savings from the three highest-value users paying the 21-token toll exceed the increased travel costs by the low-value-of-time Route B users resulting in a socially superior outcome than the user equilibrium without a toll (402 versus 420 tokens).

3 Experimental design

To answer the three research questions, we designed an environment in which we can examine both route-choice decisions and voting behavior. Subjects are assigned to groups of six for the entire experiment, and each subject makes a total of 33 decisions. Table 2 summarizes the timeline of the experiment. Subjects participate in three ten-period stages in which they make route-choice decisions. The first stage does not have a toll, while a 21-token toll exists in the second stage for those users using Route A. It is up to the group of six to determine whether there will be a toll in the third stage. At the end of the experiment, one of the three stages is randomly chosen to determine the subjects' monetary payoffs.

As seen in Table 2, participants are given a chance to vote three times to determine what happens in the third stage. The vote elicits an individual's acceptability of a toll before experiencing the congestion problem, after experiencing the congestion problem, and finally after experiencing what happens after the toll. The design closely follows the individual uncertainty modeled in [Fernandez and Rodrik, 1991] and [De~Borger and Proost, 2012], and similarly follows Stockholm's 2006 experience, with the second vote resembling the pre-trial polls and the third vote as the equivalent to the after-trial referendum. The first vote, however, tries to gauge an individual's stated preference of a Pigouvian tax in the context of a transportation problem. A group's voting outcomes are not revealed until after the third vote is cast. At that time, the experimenter has a volunteer roll a die to determine which of the three votes count for all groups in the session.[9] Each vote is then potentially binding, which provides an incentive-compatible measure of how an individual feels about the toll. Since there are groups of six, a volunteer is asked to pull from a deck of cards to determine what the tiebreaker would be if any group in the session has a 3-to-3 tie for the chosen vote. The design mitigates any endogeneity concerns for how an individual performs in Stage 1 and 2. The third stage exists primarily as a possible binding outcome that can elicit both an individual's stated and revealed preferences.

The experiment follows a 2×2 design that varies the welfare impacts of the toll and the disclosed information of the effect of the toll (see Table 3). There exist two settings: one where all participants are better off and are all "winners" with the toll (100% toll revenue redistribution) and another where there are "winners" and "losers" of the toll (40% toll revenue redistribution). Motivated by the research question on voting behavior, a second treatment varies the information that is disclosed immediately before the third vote. In one session the individual sees their average total costs of Stages 1 and 2 and the percentage change in costs, in the other they see their cost information as well as the same information for all six individual group members ranked by highest cost reduction. Observing varying outcomes of other members of the group may entice some individuals to value their experience differently and vote counter to what they otherwise would have.

[9] A session's binding stage is chosen using the same process at the entire experiment and after survey questions have been answered.

Table 2: Summary of experiment

Vote 1	Stage 1	Vote 2	Stage 2	Vote 3	Stage 3
	10 Periods *No Toll*		10 Periods *Toll*		10 Periods *Toll or no toll*

Table 3: Treatments

	Information on how the toll affects individual average costs before 3rd Vote	Information on how the toll affects individual average costs for entire group before 3rd Vote
100% Redistribution (Everyone better off)	8 group of 6 subjects	8 group of 6 subjects
40% Redistribution (Winners and Losers)	8 group of 6 subjects	8 group of 6 subjects

The earnings of individuals depend on their decisions and their value of time. Each individual is privately provided their endowment for that period. However, the language in the experiment focuses on (adjusted) cost reductions rather than changes in earnings, since most of the real-world discussion of congestion pricing is on the reduction in costs and not on the increase in consumer surplus or earnings.

Table 4 reports the theoretically predicted net earnings without the toll and the welfare effects by individual values of time and redistribution rates. These welfare impacts are the differences in net earnings when comparing the Nash equilibria with and without the 21-token toll. Note that without a toll, all earnings are the same for all individuals, and the welfare impacts of the toll have a non-linear relationship, which is consistent with previous literature. For example, within a two-route model, [Light, 2009] shows that those who are indifferent or near indifferent between the priced and the free route are among those that will be made worse off from a toll; the potentially better off groups are those with values of time at the high and low end of the value-of-time distribution. That is, individuals with the highest values of time have the most to gain from the faster speeds on the toll route while those with the lowest values of time that take the slower route are less harmed by the toll and can be potentially made better off after any revenue recycling.

Table 4 suggests that self-interested individuals should always vote for the toll when there is 100% redistribution since everyone gains, while in treatments with 40% redistribution, the individuals with a value of 3 and 4 tokens per minute should always vote against the toll. The level of the toll and the given parameters were selected because of their specific welfare effects as seen in Table 4 and to observe how sensitive individuals are to them.

Table 4: Predicted individual welfare effects from the toll (in tokens)

		Effect on costs				Effect on earnings			
Value of time	**Endowment**[a]	**Cost w/o toll**	**Cost w/ toll (No redist.)**	**Cost w/ toll (40% redist.)**	**Cost w/ toll (100% redist.)**	**Earnings w/o toll**	**Earnings w/ toll (No redist.)**	**Earnings w/ toll (40% redist.)**	**Earnings w/ toll (100% redist.)**
12	**145**	120	105	100.8 (-16%)	94.5 (-21.3%)	25	40	44.2 (+76.8%)	50.5 (+102%)
11	**135**	110	98	93.8 (-14.7%)	87.5 (-20.5%)	25	37	41.2 (+64.8%)	47.5 (+90%)
10	**125**	100	91	86.8 (-13.2%)	80.5 (-19.5%)	25	34	38.2 (+52.8%)	44.5 (+78%)
4	**65**	40	48	43.8 (+9.5%)	37.5 (-6.3%)	25	17	21.2 (-15.2%)	27.5 (+10%)
3	**55**	30	36	31.8 (+6%)	25.5 (-15%)	25	19	23.2 (-7.2%)	29.5 (+18%)
2	**45**	20	24	19.8 (-1.0%)	13.5 (-32.5%)	25	21	25.2 (+0.8%)	31.5 (+26%)
Group Total		420	402	376.8 (-10.3%)	339 (-19.3%)	150	168	193.2 (+28.8%)	231 (+54%)

[a]Participants are unaware of the endowment values of other individuals in their group.

The experiment was programmed and conducted with the software z-Tree [Fischbacher, 2007]. Subjects are given and read aloud the instructions that also had practice questions that emphasized the possible outcomes of route-choice decisions and the congestion problem. We reduce the risk of anchoring by not having any question show a positive (or negative) individual welfare impact from the toll.[10] At the beginning of the experiment, individuals know their endowment, their value of time, and how their value of time compared to the values of other group members. All subjects knew that these values would not change throughout the entire experiment.

In each period of a stage, subjects were asked which route to take: Route A or Route B. Before each decision, subjects are provided the possible time outcomes listed in Table 1 as well as their private travel costs without considering a toll for each possible outcome, and, if applicable, the level of the toll and redistribution rate. After a decision is made, subjects receive feedback on which route they took, the number of Route A users, their travel time, and their travel costs for that period, and if applicable, the period's toll revenue generated, their share of toll revenue, and adjusted travel costs after redistribution. Subjects have the option to see their history of previous decisions and number of Route A entrants.[11] Following the findings in [Anderson et~al., 2008] and [Selten et~al., 2007] that information feedback reduces variation around the equilibrium, we wanted to provide the best chance to create stable equilibria with and without a toll (i.e., generate similar experiences) so to allow comparable observations of individual attitudes toward a toll across all subject groups.

[10] A copy of the instructions for the 100% revenue redistribution treatment is provided in the online Appendix.
[11] See the online Appendix for a z-Tree screenshot of route-choice decision feedback.

Subjects participate in three referendum votes; each vote elicits the acceptability of tolling before and after being accustomed to the congestion problem and the implementation of a toll. The first vote occurs after the instructions are read and subjects are given their endowed values. The congestion problem that occurs when an additional person uses Route A is objectively explained as well as shown in the instructions' practice problems. The instructions state that the toll is set at a level that optimizes the use of Route A.[12] The redistribution rate is also stated in the instructions.

Subjects know the level of the toll at the first referendum vote as well as their endowed values–their value of time and where their value of time is distributed among the group of six the level of the toll. Since before the third vote individuals are provided information, the treatment with the ranked group information also displays performance based on values of time. By having subjects know the size of their value of time relative to the values of the group members throughout the entire experiment, subjects are then able to react to the performance information rather than the informational discovery of the value-of-time distribution of the other group members. And since the group's voting outcomes are not revealed until after the final vote, each vote discloses an individual's opinion independent of the favorability of the other group members. The opinions of other individuals have no influence on the individual's voting behavior.

4 Results

In April 2014, 192 undergraduates from Colorado State University participated in the experiment, yielding 32 group observations of 30 periods and 6336 total individual experimental observations including 576 voting observations (192 for each of the three votes). A session lasted seventy-five minutes, and the average compensation was $18.74 with a range of $11.75 to $30.25. One token in the experiment equals $0.06. Eight groups of six subjects participated in each of the four treatments. The average age was 19.3 with 93 females participating. At the end of the experiment, all subjects answered a survey that elicited demographic information and beliefs on several dimensions. The data are used to answer three research questions investigating the performance of the toll and whether the effect of accustomation can predict the acceptability of the toll.

4.1 Question 1: Does congestion pricing (a toll on a congestible route) work in the lab?

The toll should minimize total travel costs by reducing the number of Route A entrants to the three highest values of time users (users with values of 10, 11, and 12 tokens per minute). Recall that the toll incentivizes the low-value users to use Route B to minimize their travel time costs. Without the toll, all six individuals should enter Route A since, as was seen in Table 1, the highest travel time possible when using Route A (10 minutes) is still less than the (fixed) travel time when using Route B (12 minutes).

The route-choice decisions, as displayed in Table 5, suggest an affirmative answer to

[12] "Optimize throughput at free-flow speeds" was language used for explaining the toll policy goals of California 91 Express Lanes in Orange County. The Orange County Transportation Authority. http://www.91expresslanes.com/policies.asp. Accessed March 24, 2014.

Question 1. Table 5a summarizes group behavior, and reports the average number of Route A entrants, total travel time, total travel costs after revenue redistribution, and an efficiency index for the three 10-period stages.[13] As seen in Table 5a, the average number of Route A entrants in Stage 1 without a toll is near six with an average of 5.6 entrants. The same applies to those groups who self-selected to not have a toll in Stage 3; they have an average of 5.9 Route A entrants. The reported t-tests show that the stages with a toll significantly reduced the number of Route A entrants (p values are less than 0.001). In Stage 2 the average number of entrants is 3.6 and in Stage 3 those groups that self-selected to have a toll have an average of 3.5 entrants. This reduction in Route A entrants significantly improves group outcomes and increases efficiency. Note that the efficiency indices reported between Stage 1 and 2 in the 40% redistribution are significantly different when using the adjusted index ($p = 0.179$ if comparing indices without adjustment, and $p < 0.001$ when comparing the original index in Stage 1 to the adjusted index in Stage 2). The combination of toll revenue leaving the system, disproportional equity effects, and possible idiosyncrasies within groups may explain these differences in statistical significance. Therefore, examining individual route-choice decisions can provide a further understanding of the toll's effectiveness.

[13] The efficiency index normalizes travel costs to one (i.e., costs are minimized to the socially optimal level) and zero (i.e., costs at the Nash or user equilibrium). This index is calculated by using the following formula: $(UserEquilibrium - Observed)/(UserEqulibrium - SocialOptimal)$ where the user equilibrium travel cost ($UserEquilibrium$) and social optimal travel cost ($SocialOptimal$) are 420 and 339 tokens, respectively. Note that in the 40% redistribution treatment the lowest possible travel cost is 376.8 tokens (see Table 4) since not all revenue is recycled, which caps the efficiency index range to 0.533 instead of 1. As noted in Table 5a, an adjusted efficiency index accounts for this "leaky bucket" by using 376.8 and not 339 tokens as the cost-minimizing baseline so that the maximum for the index is 1 again.

Table 5: Summary of route-choice decisions

(a) Group behavior averages across periods[a]

	No Toll (Stage 1)	Toll (Stage 2)	No Toll (Stage 3)	Toll (Stage 3)
Route A entrants (out of 6)	5.6	3.6***	5.9	3.5***
Travel Time ("minutes")	59.0	57.0***	59.7	56.7***
Travel Costs (tokens)	412.8	387.6***	418.6	378.5***
Efficiency Index	0.090	0.400***	0.018	0.513***
40%[b]	*0.122*	*0.164*	*0.016*	*0.328****
		*(0.308***)*		*(0.615***)*
100%	*0.056*	*0.636****	*0.019*	*0.731****
Observations	320	320	80	240

[a] *Two-sample t-tests: ***, **, *, represent statistical differences at the 1%, 5% and 10% level, respectively, in the comparisons between samples across columns of either Stage 1 and Stage 2, or within Stage 3 samples of a given population.*
[b] *Parentheses represent the adjusted efficiency index for 40% redistribution that accounts for 376.8 and not 339 as the cost-minimizing outcome.*

(b) Percentages of individuals entering Route A by values of time and redistribution Rate

Value of Time	Redistribution Rate	No Toll (Stage 1)	Toll (Stage 2)	No Toll (Stage 3)	Toll (Stage 3)
Low value of time (efficient to use Route B)					
2	**40%**	87.5%	26.3%	100%	14.6%
	100%	96.3%	21.9%	100%	18.2%
3	**40%**	91.9%	16.3%	100%	13.1%
	100%	96.9%	43.1%	98%	28.2%
4	**40%**	93.1%	34.4%	100%	19.2%
	100%	96.9%	46.3%	98%	38.2%
High value of time (efficient to use Route A)					
10	**40%**	93.1%	87.5%	93.3%	99.2%
	100%	94.4%	85.6%	98%	97.3%
11	**40%**	95%	90%	96.7%	96.2%
	100%	95%	94.4%	100%	96.4%
12	**40%**	95.7%	88.8%	96.7%	98.5%
	100%	91.9%	90%	94%	91.8%
Observations per individual value of time					
	40%	160	160	30	130
	100%	160	160	50	110

The two-sample t-tests of the entry rates with and without a toll of users with low value of time in the first two stages were statistically different at the 1% level.

Table 5b illustrates the effectiveness of the toll by reporting entry rates by users' values of time and redistribution rates. Note that subjects did not behave strictly to the theoretical predictions. Some subjects could still be learning the game in the early periods of a stage, some could be responding to the noise observed in previous periods, or some could have idiosyncratic behavior such as altruism.[14] The results suggest that individuals mostly behaved according to the theoretical predictions, but there still exists some noise in the outcomes.[15]

Nevertheless, the results in Table 5b do indeed show that the users with the lowest value of time use Route A less intensely with a toll. The effectiveness of the toll depended on the idiosyncratic behaviors within the group. Individuals had similar experiences without the toll; the toll achieved most of the objectives of changing group behavior. The difference between the theoretically predicted outcomes and the outcomes in the lab may help explain why tolls may or may not work in practice. The results suggest that people make "mistakes" and that those marginal users that are incentivized to use alternatives to their preferable travel option (e.g., Route B versus Route A), may not always switch to the inferior alternative, and these marginal users may be rational to do so ex ante and ex post even with the policy.

Answer to Research Question 1: The toll mitigates congestion and improves group outcomes in the lab by adequately reducing Route A entrants to those users with the highest value of time.

The toll improves outcomes of the transportation system with the greatest improvement (measured reduced total travel costs) being observed when 100% of the toll revenue is allocated. The improvement is smaller with 40% redistribution which can be explained by total welfare leaving the system; however, the withholding of 60% of toll revenue obtains the intended effect of creating distributional and fairness concerns. Although the toll did not achieve a clean outcome of the three highest users strictly entering Route A, the improvements (i.e., decreased entrants, decreased total travel time, decreased travel costs, and increased measures of efficiency) in the system across both redistribution rates should affect users' acceptability, measured in votes, after experiencing the network with and without the toll.

4.2 Question 2: Does experience and resulting removal of the policy's uncertainties from a policy trial influence acceptability?

Subjects participate in three referendum votes; the votes elicit the acceptability of a toll before and after subjects are accustomed to the congestion problem and implementation of a toll. The first vote occurs before any route decisions are made and gauges a subject's initial perception of a toll given the redistribution rate and the subject's exogenously imposed value of time. This vote occurs after the instructions are read. Before casting their first vote, subjects are given information regarding their values of time and how those values are distributed among the

[14] In regards to the idiosyncrasies of subjects, one subject in the 40% redistribution and no ranked information treatment who had a value of time of 2 tokens per minute left the following comment regarding their strategy: "I made most of my decisions based on the idea that I wanted to make money myslef (sic) but understood that when other[s] sacrificed, I gained. So i (sic) tried to make decsions (sic) for myself about 70% of the time and help others on the other 30%." This type of altruistic behavior greatly benefited the group; this person took the longer route at an additional travel cost of 4 tokens ($0.24) while benefiting the other five in Route A by 40 tokens ($2.40). This is noteworthy considering users with a value of time of 2 tokens per minute have a dominant strategy of entering Route B if there is toll and regardless of *any* rate of revenue redistribution.

[15] Note that the predicted pure strategy Nash equilibrium solution with these parameters and level of the toll is not undermined by subjects correctly discounting the toll by incorporating any revenue redistribution.

group of six, the level of the toll, and the redistribution rate.

If subjects were given perfect information on the objective effects of the toll on their earnings, profit-maximizing individuals in the 100% redistribution should unanimously be for the toll while the individuals in the 40% redistribution rate with the value of times of 3 and 4 tokens per minute should be opposed to the toll. Because of this treatment effect, subjects are placed for the following analysis in one of three groups depending on their values of time: strictly better off (values of times of 10, 11, 12), weakly better off (value of time of 2), and mixed (value of times of 3 and 4). Table 6 reports the approval percentages by an individual's value of time, redistribution rate, the toll's predicted effects and actual average percentage change in costs. In the first vote, there appears to be no noticeable pattern on voting sensitivity by redistribution rate and an individual's value of time. For example, individuals in the 40% treatment appear no less likely to vote for the toll compared to those individuals in the 100% treatment.[16] And the individuals with the highest value of time, 12 tokens per minute, who have the most at stake regarding the imposition of the toll were not for the toll initially in the 100% redistribution treatment with 37.5% voted in favor. Research Question 3 explores the lack of monetary self-interest observed in the first vote by all individuals and whether individual attributes can predict voting behavior.

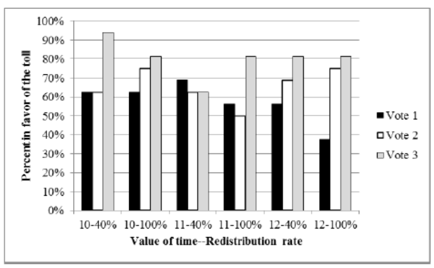
The second and third votes help measure the evolution of an individual's acceptability after experiencing the congestion problem and after experiencing a toll that mitigates the congestion problem. The reported results in Table 6 show an increase in favorability of the toll, even for the individuals in the 40% redistribution treatment that are predicted to be made worse off once the toll is introduced. Across all treatments, the percentage voting for the toll increases from 56.3% in the first vote to 61.5% in the second vote. The increase may be a response from experiencing a noticeable difference in travel costs (and gains to the system) when comparing outcomes of a period when at least one subject took Route B with a period when everyone went Route A. Such an observation would make both the problem and the described effect of the toll more salient.

[16] A two-tailed t-test yields a p-value of 0.195.

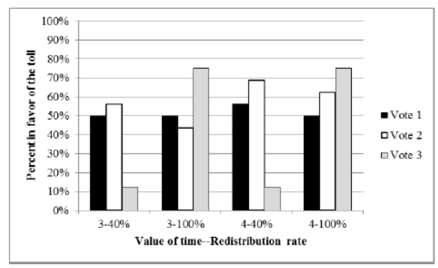
Table 6: Approval percentages by predicted outcomes by individual's value of time

Value of time	Redistribution rate	Predicted change in costs	*Average actual % change in costs*	Vote 1	Vote 2	Vote 3	Correlation coefficient (Avg. actual % change in costs and Vote 3): By redist. rate	Correlation coefficient (Avg. actual % change in costs and Vote 3): Across redist. rates
2	40%	-1%	*13.6%*	56.3%	68.8%	37.5%	0.29	-0.47**
	100%	-32.5%	*-29.6%*	37.5%	43.8%	87.5%	-0.19	
3	40%	6%	*10.9%*	50%	56.3%	13%	0.02	-0.76***
	100%	-15.0%	*-8.1%*	50%	43.8%	75%	-0.79***	
4	40%	9.5%	*15.1%*	56.3%	66.8%	12.5%	-0.18	-0.70***
	100%	-6.3%	*-5.5%*	50%	62.5%	75%	-0.51**	
10	40%	-13.2%	*-3.6%*	62.5%	62.5%	93.8%	-0.44*	-0.11
	100%	-19.5%	*-9.2%*	62.5%	75%	81.3%	-0.1	
11	40%	-14.7%	*-4.6%*	66.8%	62.5%	62.5%	0.17	-0.12
	100%	-20.5%	*-12.2%*	56.3%	50%	81.3%	-0.21	
12	40%	-16.0%	*-5.5%*	56.3%	68.8%	81.5%	-0.40	-0.15
	100%	-21.3%	*-11.7%*	37.5%	75%	81.3%	-0.02	
All	40%	-10.3%	*4.3%*	58.3%	64.6%	50%	-0.50***	-0.50***
	100%	-19.3%	*-12.7%*	49%	58.3%	80.2%	-0.29***	
	All	-14.8%	*-4.2%*	53.6%	61.5%	65.1%		

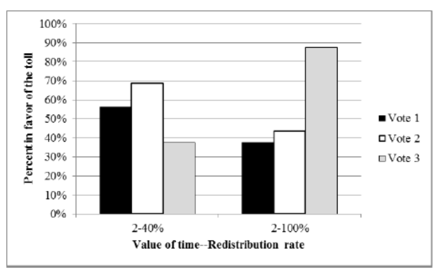
*Significant at 10%, **significant at 5%, ***significant at 1%



(a) Strictly-better-off group (value of time: 10, 11, 12)



(b) Mixed group (value of time: 3 and 4)



(c) Weakly-better-off group (value of time of 2)

Figure 2: Approval rates across three votes by sub-sample and redistribution rate

The third vote captures the acceptability of the toll after users are accustomed to the problem with and without the toll and with disclosure on objective measures on how the toll affected costs. This vote reveals an individual's subjective value on the toll's effects. Some of the subjects see additional information that shows the ranked information of other individuals in their group. Table 6 reports the varying welfare effects of the toll users observed before casting their final vote. Illustrated both in Table 6 and Figure 2, these observed and experienced effects noticeably affected the third vote.

Due to the shorter travel times, the toll allowed the higher-time-value subjects to enjoy lower travel costs despite payment of a toll, while the lower-time-value subjects were either made better or worse off by taking the longer Route B depending on the redistribution rate. As suggested in Table 6, individuals were more likely to vote in their monetary self-interest during the third vote. For all individual observations, the bivariate correlation coefficient between *Vote 3* and *Actual Percentage Change In Costs* yields a value of -0.50 (compared to correlation coefficients of 0.14 and 0.11 for the first and second votes); negative welfare effects can translate to lower acceptability. The toll for the lowest-time-value user in the 40% redistribution treatment, on average, actually increased their costs instead of an expected decline of one percent. Their favorability of the toll at the end is 37.5%. A noticeable difference in favorability of the toll in the final vote is observed between redistribution rates: 80.2% favored the toll with 100% redistribution, and 50% voted for the toll in the 40% treatment (see Table 6).[17] The correlation coefficients reported in Table 6 suggest that most individuals, especially those in the mixed group, do respond in their monetary self-interest after the trial removes the uncertainty regarding the incidence of the tolling policy.

The evolution of voting behavior by sub-sample (individuals in the strictly-better-off, weakly-better-off, and mixed groups) is displayed in Figure 2. Figures 2b and 2c illustrate noticeable differences in approval ratings between the same individual across the redistribution treatment. The toll's impact in creating "winners" and "losers" suggests that the nature of the experience matters in determining acceptability. The nature of the experience depends on the individual and the decisions made by other members in the group.

Answer to Research Question 2: The experience and accustomation of the congestion problem with and without the toll and a trial's removal of uncertainty of the policy's effects influences attitudes; monetary self-interest appears to be a major determinant on the opinion of the toll, especially for those who are made worse off from the toll.

The full experience of being accustomed to and obtaining an objective measure of the congestion problem with and without the toll appears to matter; however, not all individuals voted in their monetary self-interest. The last research question then asks, when controlling for accustomation and nature of the experience, whether individual attributes including reaction to the ranked information treatment predicts voting behavior.

4.3 Question 3: Do individual attributes determine the acceptability of tolls, and does this acceptability evolve when an individual becomes accustomed to the problem and policy?

The observation in the previous section of not everyone voting in their monetary self-interest even after being disclosed an objective measure of the effects of a toll for the third vote, suggests that individual beliefs and attitudes may be a factor in determining acceptability. Understanding how and when these personal attributes affect the evolution of acceptability of a policy may make the obstacles more clear for policymakers when implementing acceptable and efficient congestion mitigation instruments. For many constituents, attitudes might be sensitive to feelings of government intervention, equity concerns, altruism, feelings toward the

[17] The online Appendix reports referenda outcomes by treatment.

environment, and political ideology. This section will test hypotheses relating to the prediction of voting behavior controlling for beliefs, accustomation to the problem and policy, and the nature of the experience.

After the experiment, subjects participated in a survey that elicits measures of their beliefs as well as their demographic information. The question is whether these measures as well as the treatment that shows the group's ranked information on the effect of the toll predicts voting behavior. The survey includes a) questions based on research by [Kahan et~al., 2011, Kahan et~al., 2012] on how individualism and hierarchy affect opinions on scientific evidence, b) questions of environmental concerns measured on the New Ecological Paradigm (NEP) Scale, c) questions measuring altruism using aspects of Schwartz's model previously used by, for example, [Kotchen and Moore, 2007], and d) political ideology questions regarding economic and social issues.

[Kahan et~al., 2011] measures individual worldview across two dimensions: individualism-communitarianism and hierarchy-egalitarianism. Six individual statements (individualism- communitarianism) focus on "attitudes toward social orderings that expect individuals to secure their own well-being without assistance or interference from society versus those that assign society the obligations to secure collective welfare and power to override competing individuals interests" [Kahan et~al., 2011]. And six hierarchical statements (hierarchy-egalitarianism) capture the "attitudes toward social ordering that connect authority to stratified social roles based on highly conspicuous and largely fixed characters such as gender, race, and class" [Kahan et~al., 2011].[18] Subjects indicate the extent that they agree with each of the statements using a six-level Likert scale, which are translated to a score of 1 to 6 on their level of agreement towards a worldview. The sum of scores for each of the statements places their views on the respective hierarchy-egalitarianism and individualism-communitarianism spectrums (6 to 36).

Table 7: General measures of beliefs

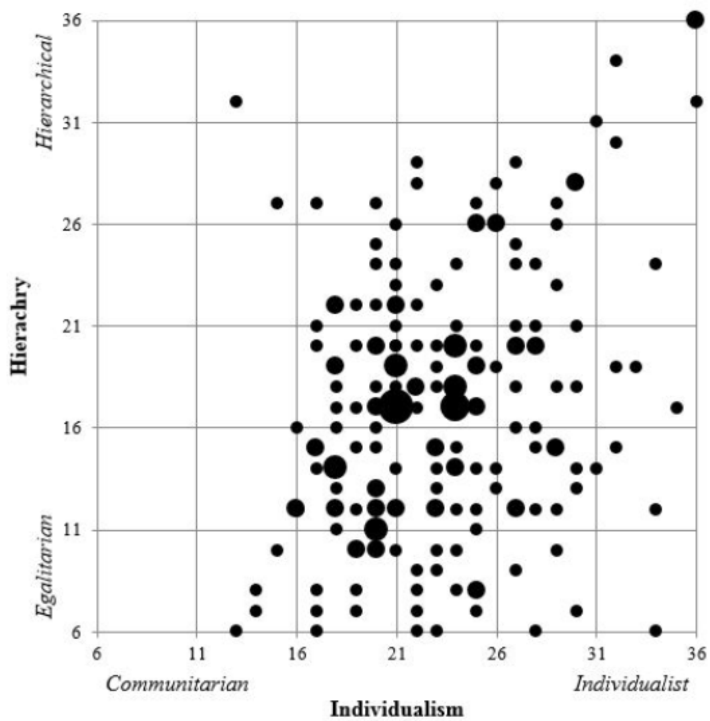
	Average	Standard Deviation	Median	Range
Individualism (6-36) *(higher value implies more individualistic)*	23.22	4.81	23	13-36
Hierarchy (6-36) *(higher value implies more hierarchical)*	17.13	6.47	17	6-36
Altruism (5-25) *(higher value implies more altruistic)*	17.27	3.36	13	5-25
New Ecological Paradigm (NEP) (5-25) *(higher value implies more concern for the environment)*	19.73	3.37	16	8-25
Stated Political Ideology (Economic Issues) *(1=Very Liberal; 2=Liberal; 3=Moderate; 4=Conservative; 5=Very Conservative)*	3.08	0.92	3	1-5
Stated Political Ideology (Social Issues) *(1=Very Liberal; 2=Liberal; 3=Moderate; 4=Conservative; 5=Very Conservative)*	2.73	1.07	3	1-5

Subjects' environmental concerns, altruistic values, and political ideologies were also included. Subjects were asked on a five-point scale whether they agree or disagree with a series

[18] The statements are reported in the online Appendix.

of five statements based on the Schwartz model of altruistic behavior [Kotchen and Moore, 2007]. Similarly, subjects indicated their concern for the environment using the same five-point Likert scale with a series of five statements based from the New Ecological Paradigm (NEP) Scale [Kotchen and Moore, 2007]. The responses for each set of respective statements can be summed to obtain measures of general concern for the environment and altruism (5-25). Finally, subjects were asked to state their political preferences on a liberal and conservative spectrum (1=Very Liberal, 2=Liberal, 3=Moderate, 4=Conservative, 5=Very Conservative) on social and economic issues.

Table 7 reports the averages of the general attitudes and worldviews. The combined individual Kahan measures of individualism and hierarchy are illustrated in Figure 3 and shows that the subjects had more individualistic feelings and were diverse on their opinions on hierarchy. Similar to [Kahan et~al., 2011, Kahan et~al., 2012] and [Cherry et~al., 2013], the hierarchy and individualism dimensions are combined where people that score above the median in both dimensions are defined as Hierarchical-Individualist and those that scored below the median in both dimensions as Egalitarian-Communitarian.



Note: densities of individuals (small mark=1 subject, largest mark=5 subjects)

Figure 3: Correlation of [Kahan et~al., 2011] worldview scores

A probit model with clustered errors by subject and instrumental variables is used on the panel data to estimate the effects of these personal attributes on voting behavior [Maddala, 1983, Cameron and Trivedi, 2005]. The panel data entails 192 individuals, i, voting 3 times, t, totaling 576 observations. The errors are clustered by subject since each individual makes three votes over time. The probability model is as follows:

$$\begin{aligned}
Pr(Vote_{it}=1|X) &= \beta_0 + \beta_1 HierarchicalIndividualist_i \\
&+ \beta_2 EgalitarianCommunitarian_i + \beta_3 Altruism_i + \beta_4 NEP_i \\
&+ \beta_5 Vote2_t + \beta_6 (Vote2_t \times HierarchicalIndividualist_i) \\
&+ \beta_7 (Vote2_t \times EgalitarianCommunitarian_i) \\
&+ \beta_8 (Vote2_t \times Altruism_i) + \beta_9 (Vote2_t \times NEP_i) \\
&+ \beta_{10} Vote3_t + \beta_{11} (Vote3_t \times HierarchicalIndividualist_i) \\
&+ \beta_{12} (Vote3_t \times EgalitarianCommunitarian_i) \\
&+ \beta_{13} (Vote3_t \times Altruism_i) + \beta_{14} (Vote3_t \times NEP_i) \\
&+ \beta_{15} (Vote3_t \times Experience) + \beta_{16} (Vote3_t \times RankTrmt_i)
\end{aligned} \tag{6}$$

A binary dependent variable, $Vote_{it}$, is used where a "yes" vote equals 1 and 0 otherwise for each i individual for one of the three votes, t. The independent variables consist of controls for the timing of the vote or accustomation to the problem or policy, and treatment effects that occur in the third vote. The following is a list of variables and their definitions:

- $Vote2$ – "Vote is second of three votes–subject is accustomed to the problem (0 or 1)"
- $Vote3$ – "Vote is the third of three votes–subject is accustomed to the problem and toll policy (0 or 1)"
- $Experience$ – "An objective measure of the percentage change in individual average costs between stage one and stage two. (-47.7 to 29.2)"
- $RankTrmt$ – "Whether third vote occurs in the group ranked information treatment – Subjects saw the effect of toll on all group members' costs. (0 or 1)"
- $HierarchicalIndividualist$ – "Above median of both Individualism and Hierarchy measures (0 or 1). On a scale of 6 to 36 Individualism measures attitudes toward social orderings that expect individuals to secure their own well-being without assistance or interference from society versus those that assign society the obligations to secure collective welfare and power to override competing individuals interests. On a scale of 6 to 36 Hierarchy measures attitudes toward social ordering that connect authority to stratified social roles based on highly conspicuous and largely fixed characters such as gender, race, and class"
- $EgalitarianCommunitarian$ – "Below median of both Individualism and Hierarchy measures (0 or 1)"
- $Altruism$ – "A measure of a subject's altruism (5-25)"
- NEP – "New Ecological Paradigm; general concern for the environment (5-25)"
- The percent predicted change in cost by subject by redistribution treatment reported in Table 6 is used to instrument for experience.

The model accounts for various experiences across subjects. In the experiment, subjects are randomly assigned to a computer and given their value of time. They bring with them just their idiosyncratic beliefs and behaviors. Any individual can affect their experience as well as the experience of other players of their group by making route-choice decisions that conflict with the model's prediction. To account for this endogenous experience, the predicted percentage change in cost of the toll reported in Table 6 is used to instrument for $Experience$ in Equation 6. Furthermore, Equation 6 is estimated for different sub-samples: subjects that are predicted to be strictly better off (value of times: 10, 11, 12), weakly better off (value of time of 2), and mixed (value of times: 3 and 4). To account for the various equity effects of congestion pricing stated in the literature, this approach allows for close examination of the relationship between beliefs, accustomation, and nature of experience on acceptability.

The coefficient estimates reported in Table 8 are estimated by sub-sample and are used to test hypotheses to answer the third research question on whether individual attributes and timing of accustomation determine the acceptability of tolls. Four hypotheses are tested. First, votes are believed to be a function of beliefs and accustomation to the problem and policy. Second, given that subjects have not encountered this problem or understand the severity of congestion, beliefs are a major factor in predicting the first vote. Third, when determining approval of the policy, subjects rely less on their beliefs after being accustomed to the problem and policy. Fourth, subjects will not vote in their monetary self-interest after experiencing the toll and given an objective measure of the nature of their experience.

4.3.1 Hypothesis 1: Votes are not a function of beliefs and accustomation of the problem and policy

As suggested by the significance of the coefficients reported in Table 10, for all individuals and across all sub samples, it appears that attitudes do depend on beliefs and accustomation of the problem and policy. Depending on the sample, some worldviews matter and the nature of experience matters. Table 9 tests the joint probability of all coefficients by sub-sample and reveals that the joint combination of the independent variables matter in predicting voting behavior (acceptability). However, although some coefficients are significant for the weakly-better off group, the joint hypothesis test for all coefficients is not rejected as reported in Table 9. The examination of the next three hypotheses will provide more nuanced inferences of how accustomation and beliefs affect acceptability.

4.3.2 Hypothesis 2: Beliefs do not predict the first vote

Across all individuals, as well as all sub-samples, individual beliefs had no significant effect on the first vote. This result can be seen by the lack of any statistical significance on any of the following first vote independent variables across all sample estimates: *HierarchicalIndividualist* (β_1), *EgalitarianCommunitarian* (β_2), *Altruism* (β_3), *NEP* (β_4). The joint hypothesis tests that all these coefficients are equal to zero across all sample estimates reported in Table 9 are unsurprisingly also not rejected.

Notability, this result conflicts with the expectation of subjects relying on their "knee-jerk" reaction when faced with an abstract Pigouvian policy intervention. Individuals were expected to rely on their beliefs and cultural cognition when facing uncertainty regarding a market-based policy intervention. The lack of any initial voting patterns before subjects are acclimated to the problem suggests that subjects could be using their best guess for the first vote; subjects may have a lack of understanding their economic situation when evaluating the policy uncertainty they face. As discussed in the interpretation of the tests of Hypotheses 3 and 4 below, it is not until individuals experience the congestion problem, but still encounter uncertainty of the potential welfare effects of the policy, do beliefs matter.

4.3.3 Hypothesis 3: Accustomation and the influence of beliefs do not change voting behavior

It is only after experiencing the problem do beliefs contribute to how an individual feels about a toll policy (see Table 8). The joint hypothesis test reported in Table 9 reflects whether the beliefs impact attitudes ex ante and ex post the experimental trial, but only after the subject is acclimated with the congestion problem. That is, the coefficients of the interaction for votes two and three are jointly compared to zero.

Based on the coefficient estimates for all individuals for the second vote reported in Table 8, those identified as Hierarchical-Individualists (10% significance), Egalitarian-Communitarians (1% significance), and those with higher measures of altruism (10% significance) were significantly more likely to vote for the policy compared to the first vote. It is only for the Egalitarian-Communitarians that the strength of these beliefs matter in determining acceptability hold ex ante and ex post in respect to the experimental trial (5% significance). It could be that these and other beliefs matter in determining initial feelings for a policy, but beliefs will matter more if individuals are given the chance to be accustomed and understand the context of the problem. After all, the instructions explicitly describe the externality problem, but individuals may first want to understand the severity of the congestion problem before confidently voting for a policy. This is consistent with the [Ison and Rye, 2005] finding that the congestion problem needs to be severe enough for the policy to gain acceptance. However, these effects from beliefs dissolve in the final vote.

The estimates by sub-sample provide a more nuanced perspective on how beliefs impact voting behavior. For both the strictly-better-off and mixed groups do Egalitarian-Communitarian views have a positive impact on the second vote (both at 5% significance). These individuals make their vote based on the uncertainties of the policy's outcomes, and their attitudes are likely motivated by their beliefs and experience with the problem to navigate through the policy's uncertainty. Interestingly, the trial's removal of uncertainty overwhelmingly diminished the this belief's impact on the favorability for the toll specifically for this group. This outcome suggests that these strictly-better-off Egalitarian-Communitarian individuals primarily base their attitudes on their beliefs ex ante, and it is not until the uncertainty of individual incidence is removed that monetary self-interest appears to matter. Similar to the result for all individuals, members in the strictly-better-off group with Hierarchical-Individualist views are more likely to vote for the toll policy during the second vote (10% significance). Also, for members of the mixed group, higher measures of altruism also increases the likelihood of voting for the policy in the second vote (10% significance).

Table 8: Probit coefficient estimates for predicting voting behavior

Dependent Variable: Vote	All Individuals	By Predicted type of individual: Strictly Better Off (Value of time 10, 11, 12)	Mixed (Value of time 3 and 4)	Weakly Better Off (Value of time 2)
HierarchicalIndividualist	-0.20 (0.25)	-0.38 (0.34)	-0.38 (0.46)	0.56 (0.544)
EgalitarianCommunitarian	-0.29 (0.23)	-0.21 (0.35)	-0.47 (0.39)	0.21 (0.62)
Altruism	-0.03 (0.03)	-0.01 (0.04)	-0.12 (0.08)	0.00 (0.7)
NEP	0.03 (0.03)	0.04 (0.04)	-0.03 (0.07)	0.10 (0.08)
Vote2	-1.10 (0.79)	-1.50 (1.25)	-1.87 (1.68)	0.44 (1.20)
Vote2×HierarchicalIndividualist	0.49 (0.26)*	0.74 (0.39)*	0.23 (0.42)	0.42 (0.74)
Vote2×EgalitarianCommunitarian	0.75 (0.27)***	1.13 (0.47)**	0.95 (0.46)**	-0.24 (0.36)
Vote2×Altruism	0.06 (0.03)*	0.07 (0.06)	0.12 (0.07)*	0.03 (0.06)
Vote2×NEP	-0.00 (0.34)	0.01 (0.05)	-0.03 (0.07)	-0.02 (0.07)
Vote3	-0.55 (0.99)	0.93 (1.36)	-4.90 (1.89)***	3.50 (2.85)
Vote3×HierarchicalIndividualist	0.44 (0.35)	0.41 (0.47)	1.37 (0.71)*	-1.37 (0.76)*
Vote3×EgalitarianCommunitarian	0.19 (0.32)	0.67 (0.64)	0.65 (0.49)	-0.93 (1.06)
Vote3×Altruism	0.01 (0.05)	-0.03 (0.06)	0.06 (0.10)	0.12 (0.13)
Vote3×NEP	0.03 (0.05)	0.01 (0.05)	0.15 (0.09)*	-0.20 (0.15)
Vote3×RankTrmt	-0.16 (0.18)	-0.31 (0.28)	0.36 (0.33)	-1.40 (0.76)***
Vote3×Experience	-0.01 (0.01)***	0.01 (0.03)	-0.02 (0.11)	-0.00 (0.01)
Constant	0.06 (0.70)	-0.19 (0.94)	3.03** (1.47)	-2.25 (1.83)
Number of observations	576	288	192	96
Number of individuals	192	96	64	32
Chi-square	35.2	35.2	37.58	26.08
p-value	0.00	0.00	0.00	0.05

Note: Standard errors in parentheses.
*Significant at 10%, **significant at 5%, ***significant at 1%

Table 9: Results of hypothesis tests

Test	All Individuals	By predicted type of individual: Strictly Better Off (Value of time 10, 11, 12)	Mixed (Value of time 3 and 4)	Weakly Better Off (Value of time 2)
Hypothesis 1: Votes are not a function of beliefs and accustomation of the problem and policy				
$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = 0$	30.28*** (14)	32.71*** (14)	34.41*** (14)	18.69 (14)
Hypothesis 2: Beliefs do not predict the first vote				
$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$	3.08 (4)	2.68 (4)	5.87 (4)	2.27 (4)
Hypothesis 3: Accustomation and the influence of beliefs do not change voting behavior				
Accustomation–timing of vote				
$H_0 : \beta_5 = \beta_{10} = 0$	2.00 (1)	4.25 (1)	6.74** (1)	1.51 (1)
Hierarchical-Individualist				
$H_0 : \beta_6 = \beta_{11} = 0$	3.97 (2)	3.41 (2)	3.70 (2)	4.07 (2)
Egalitarian-Communitarian				
$H_0 : \beta_7 = \beta_{12} = 0$	8.21** (2)	5.82* (2)	4.76* (2)	1.11 (2)
Altruism				
$H_0 : \beta_8 = \beta_{13} = 0$	3.22 (2)	2.83 (2)	2.96 (2)	0.99 (2)
NEP				
$H_0 : \beta_9 = \beta_{14} = 0$	0.72 (2)	0.07 (2)	5.11* (2)	1.89 (2)
Hypothesis 4: The nature of the experience does not affect the final vote				
$H_0 : \beta_{15} = 0$	6.93*** (1)	0.18 (1)	2.62 (1)	0.16 (1)
$H_0 : \beta_{16} = 0$	0.81 (1)	1.20 (1)	1.17 (1)	9.17*** (1)
$H_0 : \beta_{15} + \beta_{16} = 0$	0.95 (1)	1.13 (1)	1.06 (1)	9.16*** (1)

Note: Reported are chi-squared statistics with degrees of freedom in parentheses.
*Significant at 10%, **significant at 5%, ***significant at 1%

The third vote depicts attitudes after subjects experience the policy trial and the policy's uncertainty is removed. Any vote that conflicts with monetary self-interest most likely is driven by the individual's worldviews. However, as seen by the mixed group sub-sample in Table 8, the removal of uncertainty regardless of nature of experience ($Vote3$) has a negative impact on attitudes (1% significance). But beliefs do appear to be a factor in the third vote for members of the mixed and weakly-better-off groups. The likelihood of voting for the policy increases (decreases) for members of the mixed group who have stronger (weaker) views on the environment (10% significance). Hierarchical-Individualists in the mixed group were more likely to vote for the policy (10% significance) while people with the same beliefs were less likely to vote in favor of the policy when in the weakly-better-off group.[19] This outcome suggests that people's attitudes may additionally depend on where they are located on the value-of-time distribution. The Hierarchical-Individualists in the mixed group may favor the policy despite their monetary self-interest because they see it as an efficient policy for society. While the Hierarchical-Individualists in the weakly-better-off group may oppose the policy since their experience and likely observation that low-value-of time individuals can voluntarily take Route B and make society better off with little harm to themselves see that government intervention would be excessive. Such individuals may not only be voting in their monetary self-interest but may rationalize that the noise observed in the experiment of some people taking Route B is sufficient enough to justify that the problem could be worse and that any government intervention would be excessive.

The joint tests for hypothesis three reported in Table 9 provide two important findings. First, the people with Egalitarian-Communitarian beliefs appear to most rely on their beliefs regarding their attitude in accepting of an uncertain market-based policy only after being acclimated to the problem. This finding is true for all sample estimates except for the weakly-better-off group. As expected, Egalitarian-Communitarian individuals are more accepting of government intervention and are most likely to vote for the policy after experiencing the problem but still face uncertainty of the toll's effects than at any other time.[20] Second, the accustomation of the trial itself had a negative effect on the attitudes of the members of the mixed group. Recall that these individuals in the mixed group should take Route B with the policy and are either made better off or worse off depending on the redistribution treatment. The results follow the findings from [Light, 2009] and [De~Borger and Proost, 2012] where individuals should vote in their self-interest after a policy trial eliminated the individual uncertainty of the toll's effects, and that the incidences of losses (or least gains) accrue heaviest to those with intermediate values of time.

4.3.4 Hypothesis 4: The nature of experience does not matter in the final vote

The fourth hypothesis tests whether the nature of the experience and not necessarily being accustomed to the policy affects favorability. As seen for all individuals in Tables 8 and 9, experience directly affects acceptability. However, the strength of the result does not hold across sub-samples.

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[19] The weakly-better-off group contains those individuals with the lowest value of time who should switch routes with the policy. The estimated model loses significance because of the amount of variables and number of observations in this small group.

[20] This finding aligns with the Cultural Cognitition Thesis discussed by [Kahan et~al., 2012], where his study posits that egalitarian communitarians are expected to be more likely to be concerned about climate change risks than hierarchical individualists.

There also appears to be no significant treatment effect from disclosing the group performance rankings, except for members of the weakly-better-off group (1% significance). After discovering the distributional effects of the policy, these individuals may be sensitive and find it improper for the government to generate such inequitable outcomes given that switching to Route B is a low-cost substitute for these individuals. These individuals could be responding differently than the quoted subject mentioned in a previous footnote in our discussion of Question 1; they may find it disturbing that their actions generate such inequitable effects. This result suggests that policymakers need to be aware that when obtaining majority approval of congestion pricing that swing voters may be sensitive to information on the equity effects on tolls. Moreover, as reported in Table 5b and Table 6 these weakly-better-off group members made sub-optimal route-choice decisions in the 40% treatment making them worse off. Such a result suggests that the objective effects of a congestion pricing policy may not be achieved for all individuals and reveals the difficulty in predicting the ex ante behavioral route-choice responses and perceptions of these marginal users.

The results suggest that the relationship between voting and nature of an individual's experience closely overlaps with an individual's monetary self-interest or their predicted level of incidence. The results suggest that accustomation of the problem and policy, and the policy trial's removal of uncertainty and not necessarily the nature of experience matters. Such findings follow the individual and political uncertainty situations illustrated in [De~Borger and Proost, 2012]. A trial diminishes any uncertainty regarding the outcomes of the policy, and it is these mixed group or people most likely to have to adjust to the policy that will determine public acceptability. As expected, by varying whether the revenue fully compensates (or even benefits) these marginal users drives ex post attitudes. This finding suggests that policymakers must be confident that a policy's effects will generate majority favorability since they will likely implement a trial unilaterally against the will of their constituents.

Answer to Research Question 3: The combination of accustomation of the problem and policy, and individual beliefs can predict acceptability of a toll. Individual beliefs did not predict initial feelings toward the toll, but the evolution of voting behavior did depend on individual beliefs and exogenous values of time. The trial had the most significant effect on acceptability for those users near the middle of the value-of-time distribution.

The evolution of acceptability of the tolling policy suggests a bias towards the status quo. The removal of uncertainty effectively has people voting in their monetary self-interest, but some beliefs or other unobservable factors supersede this pattern. Policymakers should account for the value-of-time distribution of groups affected by the toll when considering implementing a trial or permanent program, especially for those people discussed in [Light, 2009] who have intermediate values of time. Policymakers should expect negative push back from this group of individuals, but policymakers should market towards the Egalitarian-Communitarians of this group so to initiate the approval of a policy trial.

5 Conclusion

Our experimental results provide an appealing complement in understanding how attitudes may change from the introduction of incentive-based mechanisms (i.e., trials) on environmental problems, such as using congestion pricing to manage traffic congestion.

Congestion pricing creates fairness and equity concerns and the effects of such Pigouvian policies are uncertain and are not well understood by the public. [Fernandez and Rodrik, 1991] and [De~Borger and Proost, 2012] explain that the reluctance to implementing such efficiency-improving policies that are advocated by economists may stem from a bias toward the status quo stemming from individuals' uncertainties of the policy's impacts. These concerns can explain the widespread reluctance of using of such incentive-based mechanisms, and why policymakers may have to go against the majority of their constituents to implement socially efficient policies. However, the experience of a six-month trial of congestion pricing in Stockholm revealed that public opinions can change. The initially reluctant Stockholmers ended up passing a referendum to keep the congestion pricing permanent after experiencing the policy [Winslott-Hiselius et~al., 2009, Borjesson et~al., 2012]. Stockholm's experience using a policy trial and an element of uncertainty modeled in [De~Borger and Proost, 2012] are reproduced here in a laboratory setting to observe how beliefs, accustomation, and the nature of the experience explain the evolution of acceptability in a controlled environment. Similar to the [Winslott-Hiselius et~al., 2009] survey analysis of Stockholm's experience, our results showed that the personal experience from a trial period changed acceptability and that trials can be effective in implementing initially unattractive incentive-based and efficieny-improving environmental policy measures. The results also support the [Anas and Lindsey, 2011] recommendation that it is best to hold a referendum once a trial has been implemented.

We generate situations where a congestion toll creates overall efficiency improvements but with inequitable outcomes, and in some cases makes some individuals worse off. The results show that the toll achieved the objective of reducing congestion as observed in similar laboratory congestion experiments [Selten et~al., 2007, Anderson et~al., 2008, Hartman, 2012], but unlike previous experiments, this experiment showed the effects of a toll compared to a no-toll environment on users with heterogeneous time preferences. The individuals' acceptability of the toll is primarily based on the nature of their experience and being accustomed to the problem and policy. However, we find similar findings to [Kallbekken et~al., 2011] and [Cherry et~al., 2014] where monetary self-interest did not solely determine acceptability, suggesting that acceptability goes beyond standard self-interest.

We matched voting behavior with measures of individual worldviews [Kahan et~al., 2011, Kahan et~al., 2012] as well as feelings of the New Ecological Paradigm and altruism [Kotchen and Moore, 2007] to examine what motivated voting behavior. These personal attribute measures, as well as the personal consequences of the policy, are relevant. But surprisingly, no robust patterns of negative sentiments of the tolling policy (i.e., government intervention) related to personal attributes was observed for the first vote. A key finding is that beliefs do not determine initial feelings for a toll policy and that these initial feelings did not depend on the rate of toll revenue redistribution. The expectation that these beliefs will be heavily relied upon as a heuristic for the first vote when facing uncertainties of both the severity of the problem and the policy's effects is unfounded. However, once individuals experience and become accustomed to the severity of the problem, yet still face the uncertainties of the policy's effects, do some of these beliefs matter and can predict the policy's acceptability. The results suggest that those who both stand to benefit from the policy and have strong hierarchical as well as individualistic views, unsurprisingly, are more likely to find the policy acceptable. However, an interesting finding is that those with both strong egalitarian and communitarian views are also more likely to favor the policy even if it might make them worse off. This finding suggests that individuals who are more favorable to government intervention when realizing a problem but still face uncertainty regarding the effects of the policy intervention will rely on their beliefs (i.e., worldviews) when faced with such uncertainty. The results also find other beliefs predicting the timing of acceptability.

Trials similar to the experience in Stockholm in 2006 can strongly influence the acceptability of a congestion pricing policy from the combination of accustomation, nature of the experience, and self-interested behavior. Policymakers should be aware that personal attributes may or may not matter when first introducing congestion pricing. A carefully implemented policy trial similar to the experience in Stockholm may be worth considering when implementing congestion pricing or environmental policy. Policymakers should take these results and findings into account when marketing and implementing a trial or permanent congestion policy. Understanding the sizes of the populations of different groups impacted by the congestion policy and where they fall in the value-of-time distribution is essential in predicting majority approval. Furthermore, policymakers should market the policy and the severity of the problem to those who have Egalitarian-Communitarian concerns since they are the most likely to be for trial or policy intervention even though it may be against their own monetary self-interest.

As [King et~al., 2007] state, “congestion pricing will be implemented not when it is tolerable to the prospective losers, but when it is irresistible to the prospective winners.” Policymakers must be confident before a policy trial in their predictions of the policy’s incidence among the affected groups and stakeholders in order to achieve majority acceptability. To assist creating such a majority, policymakers should be familiar with the review by [Levinson, 2010] that discusses handling equity issues so to help identify which groups to earmark revenues so to effectively compensate the hardship the congestion policy creates. But as suggested by [Eliasson, 2009], the upfront financial and administrative costs must be considered for such a policy to pass a benefit-cost test. Our results follow the [Winslott-Hiselius et~al., 2009] finding that personal consequences matter in determining acceptability and that these policy benefits should be felt and seen by the majority of users. Further, policymakers should become familiar with how worldviews and beliefs may drive attitudes when when individuals face uncertainty regarding policy making, and that such knowledge will assist in targeting and marketing an efficiency-improving policy to certain sub-groups of their constituents. Thus our findings provides evidence to the idea that some people will rely on their beliefs and worldviews as a heuristic when they decide what to do (their attitude) when they are not sure what is going on regarding the support of a policy (government) intervention.

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