Uncertainty in the Theory of Deterrence: Experimental Evidence

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Abstract: We conduct laboratory experiments to investigate the effects of deterrence mechanisms under controlled conditions. The effect of the expected cost of punishment of an individual’s decision to engage in a proscribed activity and the effect of uncertainty on an individual’s decision to commit a violation are very difficult to observe in field data. We use a roadway speeding framing and find that (a) individuals respond considerably to increases in the expected cost of speeding, (b) uncertainty about the enforcement regime yields a large reduction in violations committed, and (c) people are much more likely to speed when the punishment regime for which they voted is implemented. We also obtain a theoretical result that states that, holding the true expected cost constant, people in an uncertain environment perceive a larger expected cost of speeding in the regime with higher probability. Our results have important implications for a behavioral theory of deterrence under uncertainty.

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1. Introduction

The use of deterrence mechanisms – such as the probability of apprehension, fines, and jail sentence length – in preventing proscribed activities is theoretically well understood: increases in the expected cost of committing illegal activities will reduce the amount of crimes committed.\(^1\) The concept of deterrence is not new; written accounts date back as far as 18\(^{th}\) century, when Jeremy Bentham argued that crime was the product of the exercise of free will and could be deterred by punishment such that the expected discomfort experienced would outweigh the pleasure of engaging in the criminal activity. In the realm of economics, Becker (1968), Stigler (1970), Polinsky and Shavell (1979), and Ehrlich (1996) laid the foundation upon which the theory of deterrence rests.

From a behavioral perspective, scholars in the field of law and economics have begun asking fundamental questions about individual’s interaction with legal institutions. Sunstein (1997) and Jolls, Sunstein, and Thaler (1998) provide some of the earliest analyses on the value of combining behavioral economics and jurisprudence. This research provided a gateway for research in the area of behavioral economics and law. Garoupa (2003) provides an essay on the usefulness of behavioral economics in determining the optimal level of law enforcement. This concept applies directly to the behavioral issues that surround the theory of deterrence. One core issue is the extent to which people understand the concept of deterrence. In other words, is the decision of whether or not to engage in a proscribed activity sensitive to the expected cost? When deterrence mechanisms are not understood, the effectiveness of enforcement tools can be weakened or even nullified.\(^2\) A second important issue is the effect of uncertainty on an individual’s decision to engage in a proscribed activity. To wit, when an individual is uncertain about features of the deterrence mechanism, he or she might opt to participate in an illegal activity when it is economically sensible to refrain from participating, or \textit{vice versa}. In fact, the uncertainty that surrounds the deterrence mechanism could prove useful for deterrence purposes.

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\(^1\) For simplicity, we shall use the term “deterrence mechanism” as a catch-all phrase for all enforcement tools.

\(^2\) Harel and Segal (1999) discuss this issue by asking whether increasing certainty in sentencing and uncertainty with respect to the probability of detection can be justified because criminals do not prefer such a regime.
Empirically, examining the degree of effectiveness of enforcement mechanisms can be difficult for at least two reasons. First, isolating the degree of change of a single enforcement mechanism is challenging in field data. Simultaneous changes in multiple enforcement tools make it quite challenging to ferret out the impact of a particular mechanism on undesirable actions. Second, an individual's knowledge of the change in enforcement mechanisms is uncertain. For example, even if the probability of being apprehended (hereafter probability) for a particular crime were to increase while no other enforcement mechanism changed, should we expect an individual to accurately perceive the new chance of being caught?

The need to empirically test the application of deterrence theory has spurred a modest number of studies. Sunstein et al. (2000) test whether people believe in optimal deterrence by using survey analysis. In two separate surveys, they describe legal situations – a personal injury case and tax evasion detection by the IRS – to determine if lower (higher) probability cases warranted higher (lower) fines. No such effect is observed. From a different behavioral perspective, Baker et al. (2003) use an experimental setting to test for the effect of uncertainty in deterrence. They find that uncertainty over a deterrence mechanism increases the level of deterrence. However, the experimental framework examines the effect of uncertainty in a risky environment, not an illegal environment. There are also three studies using data from natural experiments. Bar-Ilan and Sacerdote (2001) measure the change in red lights run when the fine for running the red light changes, Ihlanfeldt (2003) measures the increase in crime due to the construction of commuter rails in Atlanta, and McCormick and Tollison (1984) measure the reduction in the number of fouls committed by NCAA division 1 men’s basketball players when the number of referees on the court increases from two to three.

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3 Becker (1968) noted that enforcement efforts and sanctions are substitutes. For example, it is often the case that decreases in the number of police officers on highways and increases in speeding fines occur simultaneously.

4 The theory of deterrence predicts that the expected cost of committing a proscribed activity should be identical. Therefore, if two situations exist and the probability is lower in one regime, we should expect a higher fine in that same regime.

5 In addition, the authors use probabilities that are not on the linear portion of the S-curve in Wu and Gonzalez (1996)
However, all of these studies are less than ideally-suited for testing deterrence theory. The case studies in Sunstein et al. (2000) are somewhat controversial, as they may invite bias from the participants. Specifically, participants in the survey could be affected by social/general distaste towards either the IRS or towards medical errors. The studies by Bar-Ilan and Sacerdote (2001) and Ihlanfeldt (2003) suffer from the fact that the individual committing the crime is uncertain about their probability and amount of the fine that will be charged. Finally, although the basketball players in McCormick and Tollison (1984) are certainly aware of the increased probability of misbehavior being detected, the estimation suffers from unintentional misclassification, as the main dependent variable — fouls — included both the number of fouls and “rebounds from box scores”. When corrected, the estimation was only significant at the 10 percent level.

Bebchuk and Kaplow (1992) note that an implicit assumption, which has been carried over to subsequent investigations of optimal policy, is that individuals accurately observe the enforcement probability set by the government. In contrast to the findings of Becker (1968), which suggest the imposition of maximal punishment with low probability, Bebchuk and Kaplow (1992) note that sanctions that are non-maximal could be optimal when individuals are imperfectly informed about the probability. Sah (1991) discusses the idea that an individual's estimate of the probability may differ from the actual probability. The use of individual characteristics in estimating the perceived probability are then utilized to examine why crime participation rates differ across societal groups that have similar

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6 It is also worth noting that the individuals involved in these surveys were third-party participants who were not directly affected by their own decisions or the choices made by other participants.

7 Note that in Bar-Ilan and Sacerdote (2001) the identification comes from the fact that fines are changing. In Ihlanfeldt (2003), it is argued that lower transportation costs reduce the cost of committing a crime. That said, it is not clear that the individual committing the crime will be certain of the probability of being apprehended or fined when they travel to a different city to commit a crime.

8 See Hutchinson and Yates (2008) for further details.

9 Bebchuk and Kaplow provide the following example: Suppose that an act causes a harm of 10. The maximum possible sanction is 500, so optimal deterrence could be achieved with a probability of at least 2%. Alternatively, one could employ a sanction of 100 and a probability of 10%. Suppose, however, that half the individuals overestimate the probability by one percentage point while the other half underestimate by the same amount. For the first regime, half face an expected sanction of 15 and the other half face a sanction of five; for the alternative regime, half face an expected sanction of 11 and half face an expected sanction of 9. Clearly, under the former regime, there will be greater over-deterrence for the individuals who overestimate the probability and greater under-deterrence for those who underestimate it.
economic fundamentals. Finally, Kaplow (1990) tackles the effect of ignorance (on the part of an individual committing an act) on the optimal enforcement of acts that may or may not be illegal. By assuming the existence of a population of informed and uninformed agents, Kaplow (1990) analyzes whether it is optimal to charge differing fines on the two groups of agents.

This paper adopts a simple model from Bebchuk and Kaplow (1992) to theoretically examine the impact of uncertainty on the expected cost of a violation. Consistent with Becker (1968), our theory predicts that perfectly informed individuals should respond to increases in the probability by curbing their participation in illegal activities. In line with Bebchuk and Kaplow (1992), we also find that non-maximal sanctions could be optimal when individuals imperfectly perceive the probability of apprehension. Indeed, our theoretical model goes further, indicating that when an individual faces two enforcement regimes that have the same expected cost when perfectly perceived, the individual will perceive the expected cost in the regime with the higher probability to be larger when imperfectly perceived. This finding provides an interesting policy twist, as it might be socially beneficial to incur the cost of increasing enforcement efforts as the regime with a higher probability of apprehension – observed with error – pays a secondary dividend due to the misperception of a higher expected cost of violation.

Despite the several attempts to empirically isolate the effect of enforcement mechanisms on the number of proscribed activities committed, there still exists a relative void in the law and economics literature regarding the impact of enforcement mechanisms that is free of uncertainty on the part of the potential malfeasant. Bebchuk and Kaplow (1992) state: “To guide enforcement policy, empirical research on this point [effect of uncertainty on the decision to commit a crime] would be useful. For example, one might attempt to infer probability perceptions from behavior, which could be accomplished in an experimental setting.” Indeed, laboratory methods offer the possibility of testing

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10 Kaplow (1990) notes two types of ignorance: (1) lack of knowledge about legal rules and (2) lack of knowledge about the characteristics of the acts.

11 An enforcement regime is both a probability of apprehension and a corresponding fine.
for effects in a controlled environment. In this light, we conduct laboratory experiments that test whether the expected cost of a violation – when subjects are certain and uncertainty about the probability of enforcement - affect the likelihood of a violation. Holding the expected cost of a violation constant, we examine the interplay between a higher probability and uncertainty over the probability in two alternative enforcement regimes. In short, we find that the perceived expected cost of a violation is higher in regimes with larger probabilities. Our experiments also shed light on whether people are more likely to comply with a regulation for which they have voted.

The remainder of this paper is organized as follows. Section 2 discusses a theoretical model of deterrence that is tailored to our experimental design, and section 3 gives the details of this design. The experimental results are presented in section 4, and we discuss our results and conclude in section 5.

2. Theory

We present a theoretical model that is adopted from Bebchuk and Kaplow (1992) and is consistent with the environment of our experimental setting. First, individuals are assumed to be risk-neutral and must decide whether or not to speed on a roadway.\footnote{Although it might seem an oversimplification to examine only risk-neutral individuals, this simplification is relatively innocuous for our purposes. If an individual’s attitude towards risk does not change over the course of an experimental session, this attitude should not affect our within-subject analysis.} If the individual decides to speed, he or she obtains a benefit equal to one from speeding. Speeding imposes a social cost, $h$, and we assume that $h < 1$ so that the harm from speeding is less than the benefit that one obtains from speeding.

The government chooses a probability, $p$, given a fine, $f$, that maximizes the sum of the individuals’ benefits less the harm caused by their decision to speed and less the enforcement costs, $x(p)$.\footnote{For simplicity, the probability is assumed to be on the linear portion of the S-curve in Wu and Gonzalez (1996), so as to avoid the need to include probability weighting in this analysis. Care is taken in the experimental setting to ensure that this assumption is not violated.} We assume that $x' > 0$ and $x'' < 0$. Additionally, it is assumed that the maximum feasible fine is $f^M$, which is equal to the individual's maximum wealth. À la Becker (1968), we assume that the
imposition of a fine is costless. Finally, it is assumed that individuals imperfectly perceive the probability. Let \( r(p) \) be the probability as observed by an individual and \( e(p) \) be the error in observing the probability, such that \( \frac{\partial e(p)}{\partial p} = k \), a constant. It is assumed that \( \frac{\partial}{\partial p} \) percent of the population systematically overestimates the probability (so that \( r_{o}(p) = p + e(p) \)), \( \frac{\partial}{\partial p} \) percent of the population systematically underestimates the probability (so that \( r_{u}(p) = p - e(p) \)), and the remainder correctly estimate the probability. The government cannot observe any individual’s perceived probability of being apprehended.

Given that \( e(p) > 0 \), \( r(p) \) differs across individuals. The government's problem is to choose \( p \) in order to maximize

\[
\frac{1}{r_{o}(p)} \int_{r_{o}(p)}^{1} h \, db + \frac{1}{r_{u}(p)} \int_{r_{u}(p)}^{1} h \, db + (1 - \frac{1}{r_{o}(p)} - \frac{1}{r_{u}(p)}) \int_{r_{u}(p)}^{1} h \, db \cdot x(p)
\]

This yields the optimal probability given below:

\[
p^{o} = \frac{x}{(f^{M})^{2}} \frac{h}{f^{M}} \int_{f^{M}}^{1} 2(1 + \int_{f^{M}}^{1}) ke(p).
\]

Note that the optimal probability would be \( p^{o} = \frac{xh^{f^{M}}}{(f^{M})^{2}} \) if the individual's perception were accurate.

Thus, the expected cost of speeding, \( E \), with certainty and with uncertainly, is respectively

\[
E_{c} = \frac{x}{f^{M}} \int_{f^{M}}^{1} h
\]

\[\text{Since the imposition of a fine is costless, we assume that the maximum feasible fine is imposed, unless otherwise stated.}\]

\[\text{Note that } + _{-} \leq 1.\]
If the government were to increase the probability of being apprehended, this would lead to the following respective impacts on the expected cost of speeding

\[ \frac{\partial E_C}{\partial p} = \frac{x}{f^M} \] (5)

\[ \frac{\partial E_U}{\partial p} = \frac{x}{f^M} 2(\square + \square) f^M k e(p) \] (6)

Using the optimal probability as a starting point, it is evident that an increase beyond the optimal probability will actually increase the expected cost of speeding when individuals are certain about the probability. However, the relationship between an increase in the probability and the change in the expected cost of speeding is less clear in the case of uncertainty. Namely, the effect of a change in the probability on the expected cost of speeding depends on the relationship between the error and the actual probability, as seen in equation (6). If \( k \) takes on negative values (i.e., the error decreases as the probability increases), then the expected cost would increase. If, however, \( k \) takes on positive values (i.e., the error increases as the probability increases), then the expected cost would decrease; in this case, greater uncertainty would lead to people choosing to speed when it is not economically sensible to do so.

The effect of uncertainty on the expected cost of speeding is now discussed further. We examine two different regimes (probability and fine combination) that have the same expected cost of speeding. For simplicity, suppose that \( f_a < f_b \), but \( p_a > p_b \) such that \( f_a p_a = f_b p_b \). Using equation (2), we can solve for...
the optimal probability in each regime, given the fine. The expected cost of speeding in each regime can then be determined

\[ E_a = \frac{x'}{f_a} h \cdot 2(\square + \square)ke(p_a) \] (7)

\[ E_b = \frac{x'}{f_b} h \cdot 2(\square + \square)ke(p_b) \] (8)

Comparing equations (7) and (8), it can be shown that \( E_a \geq E_b \).\(^{16}\) Thus, when individuals face two potential enforcement regimes – with the same expected cost - but are uncertain about the regime that will actually be in place, they perceive a larger expected cost of speeding in the regime with the higher probability.

With this theory in hand, we experimentally test the effect of uncertainty on an individual’s decision to speed or not; this will provide some insight concerning \( k \), the relationship between the perceived and the actual probability of being apprehended. In addition, our test of whether people respond to higher expected costs of speeding by being more likely to refrain from speeding reflects on the findings of Sunstein et al. (2000).

### 3. Experimental Design

We conducted nine experimental sessions at the University of California at Santa Barbara. Participants were recruited using ORSEE (Greiner 2004) from a campus-wide database of students who had registered for participation in paid experiments. A total of 125 students participated in the experiment, with no person permitted to participate in more than one session. Average earnings for an experiment lasting less than one hour were about $15, including a $5 payment for showing up on time. Each session had an odd number of people present (to avoid ties in the voting stage described below).

\(^{16}\) Differencing \( E_a \) and \( E_b \) yields \( k^2 \frac{x'}{2(\square + \square)}\frac{1}{f_a} \frac{1}{f_b} > 0 \).
One consideration was how to choose a proscribed activity. While we could ask the participants about serious crimes such as murder, extortion, etc., we thought it would be unlikely that they would indicate they would choose such activities, even in the lab. Thus, we wished to find a proscribed activity in which people frequently engage, as this seemed more likely to avoid strong emotional connotations. Speeding seems a natural choice that has also been discussed empirically discussed (see Ashenfelter and Greenstone (2004) and DeAngelo and Hansen (2008)).

We had two experimental settings. In both, we had 30 periods, which consisted of three blocks of 10 periods. In each period, a participant faced a choice of whether or not to speed. If the participant chose not to speed, the payoff for that period was $0.60. If the participant instead chose to speed, the payoff for the period was $1.00 less a possible fine if caught. Sample experimental instructions are given in Appendix A.

We first describe the first experimental setting, in which 87 people participated. In periods 1-10, people were first told that there was a 50% chance of being in each of two regimes. In regime 1, the probability of being caught was 1/3 and the fine if caught was $0.90; in regime 2, the probability of being caught was 2/3 and the fine if caught was $0.45. After being so informed, participants then decided whether or not to speed. The expected fine from speeding was $0.30 in each case, so that a risk-neutral person should prefer to speed in either regime. In periods 11-20, people first voted for either regime 1 or regime 2. The regime receiving the most votes was implemented and the participants were informed of the applicable regime; the decision of whether or not to speed then followed. In periods 21-30, we introduced two new regimes. In the first of these, the probability of being caught speeding was 3/5 and the fine if caught was $0.833; in the second, the probability of being caught speeding was 4/5 and the fine if caught was $0.625. Thus, the expected fine if one chose to speed was $0.50 in each of these regimes, so that a risk-neutral person should choose not to speed in either regime.

Our second experimental setting, in which 38 people participated, was intended to control for
the possibility that the act of voting changed one’s preferences. As before, in periods 1-10, people were first told that there was a 50% chance of being in each of two regimes. In regime 1, the probability of being caught was 1/3 and the fine if caught was $0.90; in regime 2, the probability of being caught was 2/3 and the fine if caught was $0.45. However, in periods 11-20, people were told with certainty which of these regimes would apply in the next period; these regimes were varied in rounds 11-20. Finally, periods 21-30 were the same as periods 11-20 in our first setting: people first voted for either regime 1 or regime 2. The regime receiving the most votes was implemented and the participants were informed of the applicable regime.

4. Experimental Results

We find strong evidence that people are less likely to speed when there is uncertainty over which regime will apply, when the expected cost of speeding is higher, and when the regime that an individual has voted against is actually implemented. In this section, we first discuss each setting in turn, providing summary statistics and nonparametric statistical tests based on each individual’s tendencies. We then present comprehensive regression analysis for both settings.

4.1 Results for Setting 1

Figure 1 provides a visual illustration of the overall speeding rates in setting 1, according to each 10-period block (block 1 represents periods 1-10, block 2 represents periods 11-20, and block 3 represents periods 21-30). Table 1 provides more detailed information.
Figure 1 - Speeding rates by block of periods, Setting 1

![Graph showing speeding rates by block.]

Table 1 – Speeding rates by block of periods, Setting 1

<table>
<thead>
<tr>
<th>Block</th>
<th>Overall rate</th>
<th>Observations, regime 1</th>
<th>Rate in regime 1</th>
<th>Observations, regime 2</th>
<th>Rate in regime 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.616 (.016)</td>
<td>461</td>
<td>.616 (.023)</td>
<td>409</td>
<td>.617 (.024)</td>
</tr>
<tr>
<td>2</td>
<td>.685 (.016)</td>
<td>513</td>
<td>.671 (.021)</td>
<td>357</td>
<td>.706 (.024)</td>
</tr>
<tr>
<td>3</td>
<td>.424 (.016)</td>
<td>686</td>
<td>.461 (.019)</td>
<td>184</td>
<td>.288 (.033)</td>
</tr>
</tbody>
</table>

Standard errors are in parentheses

Figure 1 shows a modest difference between the speeding rates in block 1 and block 2, with a large difference in speeding rates between block 2 and block 3. Recall that the difference between block 1 and block 2 is that people did not know which regime applied to them in block 1, while they voted on a regime and were told which regime would apply in block 2. Thus, the difference indicates the effect of uncertainty regarding the regime in place, although this could also be affected by the act of voting for a regime. This difference in speeding rates is statistically significant according to the nonparametric binomial test (see Siegel and Castellan 1988), using each individual’s overall speeding rates in blocks 1 and 2. The speeding rate was higher in block 2 than in block 1 for 40 people, the

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17 We can use this test because we have within-subject data on the various blocks and regimes. The logic of this test is that if people are behaving randomly, we should expect as many people to speed more frequently in regime 1 as there are people who speed more frequently in regime 2. If these numbers differ a great deal, this indicates that behavior is not
same for 33 people, and lower for 14 people, yielding $Z = 3.54$ and $p = 0.000$. The larger difference in speeding rates between blocks 2 and 3 is also statistically significant according to the nonparametric binomial test; the speeding rate was higher in block 2 than in block 3 for 61 people, the same for 23 people, and lower for only three people, yielding $Z = 7.25$ and $p = 0.000$; recall that the difference between blocks 2 and 3 is that the expected cost of speeding is 0.3 units in block 2 and 0.5 units in block 3. Thus, behavior is quite sensitive to the expected cost.

Table 1 also breaks down speeding behavior according to the regime in place. Since people did not know ex ante which regime was in place in block 1, it is reassuring that the speeding rates were nearly identical for each regime. In block 2, when people are able to vote for regime 1 (with a 1/3 chance of detection and a 0.90 fine if detected speeding) or regime 2 (with a 2/3 chance of detection and a 0.45 fine if detected speeding), we see that 59.0% of the votes were for the regime with a higher fine and a lower probability of detection. However, there is no significant difference in the speeding rate depending on the regime in place in block 2; the binomial test gives $Z = 1.04$ and $p = 0.298$. The preference for regime 1 over regime 2 (respectively, a fine of 0.625 units with a probability of detection of 4/5 versus a fine of 0.833 with a detection probability of 3/5) is stronger in block 3, with 78.9% of the votes for regime 1. In this case, we do have a substantial and significant difference in speeding rates depending on the regime; the binomial test gives $Z = 3.88$ and $p = 0.000$.

Why do people both prefer regime 1 and speed more frequently under regime 1 in block 3? It turns out that there is a striking relationship between the choice of whether to speed in a regime and whether or not the person had voted in favor of this regime. This is illustrated in Figure 2, which shows speeding rates in blocks 2 and 3 depending on whether one voted for the regime actually implemented.

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18 In this paper, we round off each $p$-value to the third decimal place. All tests are two-tailed, unless otherwise indicated.
The differences are large (22-23 percentage points in each block) and highly significant; the binomial test gives $Z = 3.75$ and $p = 0.000$ for block 2 and $Z = 4.20$ and $p = 0.000$ for block 3.

4.2 Results for Setting 2

Figure 3 provides a visual illustration of the overall speeding rates in setting 2, according to each 10-period block. Table 2 provides more detailed information.
Figure 3 - Speeding rates by block of periods, Setting 2

![Speeding rates by block of periods, Setting 2](image)

Table 2 – Speeding rates by block of periods, Setting 2

<table>
<thead>
<tr>
<th>Block</th>
<th>Overall rate</th>
<th>Observations, regime 1</th>
<th>Rate in regime 1</th>
<th>Observations, regime 2</th>
<th>Rate in regime 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.579 (.025)</td>
<td>217</td>
<td>.567 (.034)</td>
<td>163</td>
<td>.595 (.039)</td>
</tr>
<tr>
<td>2</td>
<td>.711 (.023)</td>
<td>191</td>
<td>.639 (.035)</td>
<td>189</td>
<td>.783 (.030)</td>
</tr>
<tr>
<td>3</td>
<td>.721 (.023)</td>
<td>342</td>
<td>.719 (.024)</td>
<td>38</td>
<td>.737 (.073)</td>
</tr>
</tbody>
</table>

Standard errors are in parentheses

Figure 1 shows a difference between the speeding rates in block 1 and block 2, with no difference in overall speeding rates between block 2 and block 3. Recall that the difference between block 1 and block 2 is that people did not know which regime applied to them in block 1, while they were told the applicable regime in block 2. Thus, this provides a particularly clean test of the effect of uncertainty on the decision to speed, as in setting 2 there is no voting in block 2. This difference in speeding rates is statistically significant according to the binomial test, using each individual’s overall speeding rates in blocks 1 and 2. The speeding rate was higher in block 2 than in block 1 for 17 people, the same for 15 people, and lower for six people, yielding $Z = 2.29$ and $p = 0.022$. The very small

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19 We also note that there is no significant difference between speeding rates in block 1 of settings 1 and 2, which is reassuring since they are identical decisions. The Wilcoxon rank sum test (See Siegel and Castellan 1988) gives $Z = 0.08$. 

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difference in speeding rates between blocks 2 and 3 (which differ only in that people voted on regimes in block 3) is not statistically significant, as the speeding rate was higher in block 2 than in block 3 for 17 people, the same for 10 people, and lower for 11 people, yielding $Z = 1.13$ and $p = 0.258$.

Table 2 also breaks down speeding behavior according to the regime in place. Once again, people did not know \textit{ex ante} the regime that would be in place in block 1, and we see that the speeding rates are similar for each regime (the binomial test for differences gives $Z = 0.83$ and $p = 0.406$). In block 2, people speed more frequently in regime 2 (with the lower detection rate); however, while the difference amounts to 14.4 percentage points, it is not statistically significant; the binomial test gives $Z = 1.51$ and $p = 0.131$.

The preference for regime 1 over regime 2 (respectively, a $1/3$ chance of detection and a 0.90 fine if detected speeding versus a $2/3$ cost of detection and a 0.45 fine if detected speeding) is quite strong in block 3, with a remarkable 90.0% of the votes for regime 1. Here we have a very small and insignificant difference in speeding rates depending on the regime. However, once again there is a striking relationship between the choice of whether to speed in a regime and whether or not the person had voted in favor of this regime. This is illustrated in Figure 4, which shows speeding rates in block 3 depending on whether one voted for the regime actually implemented.
The speeding rate is double (90.0% versus 45.0%) when the participant had voted for the regime that was implemented; this difference in speeding rates is significant; the binomial test gives $Z = 2.65$ and $p = 0.008$.

Before turning to our regression analysis, we would like to comment on one aspect of our results in both settings, which reflects on our theoretical result that people will perceive a larger expected cost of speeding in the regime with the higher probability. In our experiments, participants should vote for the regime that has the smaller perceived cost of speeding. We see that people vote more often for the regime with the higher fine and the smaller probability of detection. Thus, in all cases, people prefer a higher fine and a smaller chance of detection, so that the regime with a higher probability and a lower potential fine is less attractive to would-be speeders. This result is consistent with our theoretical derivation under uncertainty. If the goal of a policy-maker is to make speeding unattractive to drivers, choosing this latter regime should be more effective; this is particularly true.

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Recall that in block 2 of setting 1, 59.0% of the votes are in favor of regime 1 (with a detection probability of 1/3 and a potential fine of 0.90 units as opposed to a detection probability of 2/3 and a potential fine of 0.45 units with regime 2). This tendency is more pronounced (with the same regimes) in block 3 of setting 2, where 90.0% of the votes are in favor of regime 1. Finally, in block 3 of setting 1, 78.9% of the votes are in favor of regime 1 (with a detection probability of 3/5 and a potential fine of 0.833 units as opposed to a detection probability of 4/5 and a potential fine of 0.625 units with regime 2).
since people are much more likely to speed when the regime for which they voted is in place.

4.3 Regression analysis

We present a separate series of regressions for each setting. Table 3 shows some regressions for setting 1:

**Table 3: Random-effects Probit Regressions for Determinants of Speeding in Setting 1**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>(1) Speeding</th>
<th>(2) Speeding</th>
<th>(3) Speeding (B2 &amp; B3)</th>
<th>(4) Speeding (B2 &amp; B3)</th>
<th>(5) Speeding (B2 &amp; B3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>-0.282***</td>
<td>-0.275***</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.074)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 3</td>
<td>-0.972***</td>
<td>-0.992***</td>
<td>-1.129***</td>
<td>-0.105</td>
<td>-0.103</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.075)</td>
<td>(0.083)</td>
<td>(0.244)</td>
<td>(0.245)</td>
</tr>
<tr>
<td>Regime</td>
<td>-</td>
<td>-0.104</td>
<td>-0.280***</td>
<td>0.090</td>
<td>0.072</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.064)</td>
<td>(0.089)</td>
<td>(0.124)</td>
<td>(0.168)</td>
</tr>
<tr>
<td>Vote match</td>
<td>-</td>
<td>-</td>
<td>0.804***</td>
<td>0.796***</td>
<td>0.755***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.083)</td>
<td>(0.084)</td>
<td>(0.282)</td>
</tr>
<tr>
<td>Block 3*Regime</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.777***</td>
<td>-0.779***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.177)</td>
<td>(0.177)</td>
</tr>
<tr>
<td>Vote match *Regime</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.201)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.571***</td>
<td>0.718***</td>
<td>0.694***</td>
<td>0.197</td>
<td>0.221</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.120)</td>
<td>(0.158)</td>
<td>(0.194)</td>
<td>(0.249)</td>
</tr>
<tr>
<td>Rho</td>
<td>0.534***</td>
<td>0.534***</td>
<td>0.534***</td>
<td>0.536***</td>
<td>0.587***</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.036)</td>
<td>(0.035)</td>
<td>(0.038)</td>
<td>(0.039)</td>
</tr>
<tr>
<td>N</td>
<td>2610</td>
<td>2610</td>
<td>1740</td>
<td>1740</td>
<td>1740</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-1312.7</td>
<td>-1311.4</td>
<td>-827.6</td>
<td>-817.8</td>
<td>-817.8</td>
</tr>
</tbody>
</table>

Standard errors are in parentheses; ***, **, and * indicate significance at $p = 0.01$, $p = 0.05$, and $p = 0.10$. Specifications (3)-(5) include data only from blocks 2 and 3. Vote match =1 if the individual voted for the regime that was implemented. We use clustered standard errors at the level of the individual subject.

Specification (1) tests for unconditional differences in speeding rates across blocks. As we found in our nonparametric tests, the speeding rate in block 1 is significantly lower than in block 2 (the omitted category) and the speeding rate in block 3 is significantly lower than in block 2. Specification
(2) adds the regime; overall, this is just short of marginal significance, with a slight tendency to speed less under regime 2 (lower fine, higher probability of detection). Specifications (3)-(5) adds the factor of whether the individual voted for the implemented regime; since voting is only permitted in blocks 2 and 3, we only include the data from these blocks in the regressions. We see that, as seen in Figures 2 and 4, people are much more likely to speed when their preferred regime is in force. While specification (3) indicates that people are significantly less likely to speed under regime 2, the interaction term in specification (4) shows that this effect is entirely driven by behavior in block 3. Finally, there is no difference across regimes in the effect of having vote for the implemented regime.

Table 4 shows similar regressions for setting 2:

**Table 4: Random-effects Probit Regressions for Determinants of Speeding in Setting 2**

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>(1) Speeding</th>
<th>(2) Speeding</th>
<th>(3) Speeding (B1)</th>
<th>(4) Speeding (B2)</th>
<th>(5) Speeding (B3)</th>
<th>(6) Speeding (B3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block 1</td>
<td>-0.544***</td>
<td>-0.507***</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Block 3</td>
<td>0.074 (0.119)</td>
<td>0.222* (0.127)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Regime</td>
<td>-</td>
<td>0.367*** (0.109)</td>
<td>0.092 (0.224)</td>
<td>0.571*** (0.169)</td>
<td>-0.382 (0.336)</td>
<td>0.429 (0.640)</td>
</tr>
<tr>
<td>Vote match</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.299*** (0.263)</td>
<td>2.917*** (1.151)</td>
</tr>
<tr>
<td>Vote match *Regime</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-1.225 (0.887)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.744*** (0.096)</td>
<td>0.180 (0.191)</td>
<td>-0.368 (0.344)</td>
<td>-0.098 (0.307)</td>
<td>1.027** (0.476)</td>
<td>-0.263 (0.827)</td>
</tr>
<tr>
<td>Rho</td>
<td>0.575*** (0.035)</td>
<td>0.577*** (0.034)</td>
<td>0.869*** (0.030)</td>
<td>0.487*** (0.087)</td>
<td>0.766*** (0.075)</td>
<td>0.666*** (0.075)</td>
</tr>
<tr>
<td>N</td>
<td>1140</td>
<td>1140</td>
<td>380</td>
<td>380</td>
<td>380</td>
<td>380</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-496.0</td>
<td>-490.2</td>
<td>-127.1</td>
<td>-190.6</td>
<td>-128.2</td>
<td>-127.7</td>
</tr>
</tbody>
</table>

Standard errors are in parentheses; ***, **, and * indicate significance at $p = 0.01$, $p = 0.05$, and $p = 0.10$. Specifications (3)-(5) include data only from blocks 2 and 3. Vote match =1 if the individual voted for the regime that was implemented. We use clustered standard errors at the level of the individual subject.

Specification (1) tests for unconditional differences in speeding rates across blocks. The
speeding rate in block 1 is significantly lower than in block 2, showing the effect of uncertainty on speeding rates, while there is no difference between speeding rates in blocks 2 and 3. When the regime is added in specification (2), the speeding rate in block 3 becomes marginally higher than in block 2, and the coefficient on regime is significantly positive. Specifications (3)-(5) indicate that this is entirely driven by block 2, where there is a somewhat higher speeding rate under regime 2. Once again, whether one voted for the implemented regime is a significant factor in specifications (5) and (6); recall that there is no voting in block 2 in setting 2. No other coefficients are significant in specifications (5) and (6), with the direction of the coefficient for regime reversing when the interaction term is included. Thus, we see that, once again, there is less speeding with uncertainty (comparing block 2 – the omitted variable – to block 1) and that the speeding rate is quite sensitive to whether or not one has voted for the regime that has been implemented.

The results from the experimental sessions support two main findings from the theoretical discussion. First, subjects decrease the amount that they speed when uncertainty exists; \( k \) takes on negative values. Second, when there is uncertainty about the probability of apprehension, a higher probability of apprehension yields a larger expected cost of committing violations.

5. Discussion

The theory of deterrence has implications for the prevention of proscribed activities, the level of punishment that individuals receive when committing a violation, the awards of a judge or jury (e.g. compensatory, punitive, and nominal damages), and the policies that should be instituted to prevent violations. Understanding the deterrence mechanisms that can be implemented and their expected effect on prevention of violations has very serious implications for society. Two key features of our analysis include (a) whether people understand the concept of deterrence (i.e., is the frequency of proscribed behavior sensitive to the expected cost) and (b) whether it is worth implementing a higher
probability regime that is costlier than a lower probability regime with the same expected cost. The answers to these questions are important not only for the prevention of speeding on roadways, but are also relevant for much larger issues such as the prevention of tax evasion, burglary, homicide, and medical malpractice.

Empirical data that permits a careful examination of the impact of enforcement regimes on proscribed activities is very difficult to obtain. An even more difficult data-acquisition task arises when one attempts to test for the effect of uncertainty pertaining to the enforcement tool on an individual’s incentive to commit a violation. Although there are many reasons why this task is so daunting, one such reason is that field data pertaining to an individual’s decision to commit a violation is difficult to track and, even if collected, would be incomplete because of the overwhelming number of violations committed but not detected. Given the difficulty in obtaining accurate and complete field data, we performed laboratory tests of whether or not people understand deterrence and of the effect of uncertainty on deterrence tools. The experimental setting provides the ability to inject and extract uncertainty from the deterrence mechanisms that the participants in the experiments face, allowing us to discern the impact of the uncertainty on the decisions of subjects.

When using scenarios to understand the impact of uncertainty on the effectiveness of deterrence mechanisms, Sunstein et al. (2000) draws our attention to the fact that subjects might not understand the concept of optimal deterrence. In contrast to the findings in Sunstein et al. (2000), however, we find that individuals do understand the deterrence mechanism. As noted in setting 1, the speeding rates decreased significantly when moving from block 2 to block 3 (when the expected cost of speeding increased). Given that students have experience with the decision to speed in the field, our experiment would seem to have considerable external validity.

One potential aspect of the theory of deterrence that has been theoretically discussed but has received very little empirical attention is the effect of uncertainty about the magnitude of a deterrence tool, from the perspective of the potential violator. For example, people who are considering
committing a crime most likely do not accurately perceive the probability of being apprehended; instead, they perceive their probability with some level of error. A similar argument can be made about the punishment that an individual will receive for committing a crime, as they might not know how a judge/jury would rule. Although Bebchuk and Kaplow (1992) and Sah (1991) have discussed the effect of uncertainty on the perception of the probability in theoretical settings, the effect has not been examined empirically. Moreover, the comparison of alternative enforcement regimes – both theoretically and empirically – does not appear to be discussed in the law and economics literature.

In order to examine the effect of uncertainty on the individual’s decision of whether or not to violate a rule, block 1 in both settings offered two equally likely enforcement regimes with identical expected costs. The uncertainty about which regime would actually be in place provided the uncertainty about the probability. The participants in the experiment understood that each regime was equally likely and, ex ante, had to decide whether or not to speed. However, in blocks 2 and 3 of setting 1, the individuals first voted on a regime and were then told which regime was in place. The removal of uncertainty allows us to both understand the effect of uncertainty as well as the perception of the relative expected costs. The removal of uncertainty increased the likelihood that individuals would choose to speed. In addition, since individuals speed more frequently when the probability of detection is lower (see Tables 1 and 2), this seems consistent with the theory that expected costs are perceived to be lower in a regime with a lower probability and a higher fine, even though the mathematical expected costs are the same.

These findings provide interesting policy implications. First, it appears that removing uncertainty about the probability leads individuals to violate more than they would in the presence of uncertainty. Second, it appears that a policy-maker should prefer the high probability/low fine regime, since people appear to speed less frequently in this case. However, a caveat to this statement is that one

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21 In the roadway speeding environment it is true that knowledge of the fines is available to all potential violators. However, most individuals are not accurately informed about these fines. Moreover, judges often allow violators to plead a lesser charge.
must also consider that increases in the probability can only be accomplished by increases in enforcement efforts, so that we must be mindful of the costs of increasing the probability in the light of the social harm that arises from violations.\footnote{This conclusion is in contrast to the findings in Becker (1968) where the maximal fine and lowest probability are implemented.}

If we can extend alternative regimes in this paper to situations when damages can be assessed, we can say more about the amount of punitive damages. In particular, we can comment on the levels of punitive damages that should be assessed when an individual violates. To start, it appears that the expected cost is perceived to be larger when there are lower fines and higher probabilities relative to lower probabilities and higher fines, despite the fact that the expected costs are identical. Therefore, if an individual commits a violation in the high probability/low fine environment, it would seem that they value the violation at a level that is greater than the perceived expected cost. If the purpose of punitive damages is to deter the individual from committing the crime in the future, then imposing a positive level of damages is justified in this environment.

Similarly, in a low probability/high fine environment, an individual that commits a violation might perceive the expected cost as being smaller than the actual expected cost.\footnote{As noted in Sunstein et al (2000), a low probability of apprehension could suggest stealthiness on the part of the perpetrator. This claim is not refuted in our analysis; however, it should be noted that a lower probability of apprehension could appear to encourage stealthiness because the expected cost is perceived to be lower (relative to a higher probability/low fine combination that has equivalent expected costs).} In this instance, it would seem less reasonable to assess lower punitive damages, if any at all. This line of reasoning does have a particular intuitive appeal. Individuals that are aware that they will be inspected frequently but still commit a violation are more negligent than an individual that is inspected infrequently. Thus, we should assess higher punitive damages to those individuals that are more negligent.

On a final policy note, the voting on regimes in this experiment provides evidence about the behavior of drivers when they vote in favor of/against a regime. That is to say, when individuals vote for a regime, they tend to speed considerably more frequently in that regime than when they vote
against the regime that is instituted. Therefore, it would seem that implementing the regime that is less desired by the potential violators will lead to a reduction in the number of violators.

References


Appendix A – Sample Experimental Instructions

Experiment Instructions – Setting 1

General Rules: No talking. No use of cell phones. No looking at neighbor's screens.

You are about to participate in an experiment on decision-making carried out by a graduate student researcher from the University of California at Santa Barbara. During this session, you can earn money. The amount of your earnings depends on your decisions and on the decisions of the other participants in this session. The session consists of 30 rounds. Your earnings will be determined by randomly choosing one payout from rounds 1-10, 11-20, and 21-30. The payout mechanism is explained in detail below. Your earnings will be paid to you in cash in private.

Your decisions are anonymous and confidential.

The experiment is split into 2 separate sections. The first section consists of 10 rounds and the second consists of 20 rounds. Instructions for the first 10 rounds are provided below. Instructions for the last 20 rounds will be given upon completion of the first 10 rounds.

Rounds 1-10: You are attempting to travel to the same destination 10 separate times - much like a commuter travels to work every day - and will receive a payout for each separate trip. You will have the option to speed or not when traveling. There will be two potential enforcement regimes - which you will be told before deciding whether to speed or not - and the probability that either regime will be instituted is equally likely. An enforcement regime is both a probability of getting caught when speeding and a corresponding fine, denoted $f$, that will be imposed if you are caught speeding. An individual that speeds and arrives at the destination without being apprehended will receive a payout of $1.00 per round. An individual that speeds and is apprehended for speeding receives a payout of $1.00 - f per round, where $f$ is the fine that is imposed by the enforcement regime that is instituted. Note that $0 < f < 1$ always. Lastly, an individual that obeys the law and does not speed receives a payout of $0.60 per round.

Examples

There are two potential enforcement regimes:

Regime A: Chance of getting caught = 33%, Fine = $0.90

Regime B: Chance of getting caught = 66%, Fine = $0.45

Regime A and Regime B are equally likely - i.e. there is a 50% chance that either regime is randomly chosen.

Situation 1: Regime A is randomly selected. There are three possible payouts:
Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.10 (= $1.00-$0.90).

Situation 2: Regime B is randomly selected. There are three possible payouts:
Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.55 (= $1.00-$0.45).

Payouts: The payout that you will receive for rounds 1-10 will be determined by randomly choosing one of the 10 rounds and then multiplying the payout of that round by 10. Consider the following possible payouts:

Example Payout 1: Suppose that round 5 is randomly chosen as the payout round and that you decide to not speed in round 5 and so your payout for round 5 is $0.60. Therefore, your payout for rounds 1-10 is $6.00 (=10*$0.60).

Example Payout 2: Suppose that round 3 is randomly chosen as the payout round and that you decide to speed in round 3 and were not caught and so your payout for round 3 is $1.00. Therefore, your payout for rounds 1-10 is $10.00 (=10*$1.00).

Example Payout 3: Suppose that round 7 is randomly chosen as the payout round. In round 7 you decided to speed, Regime A is instituted and you are caught speeding. Your payout for round 7 is $0.10. Therefore, your payout for rounds 1-10 is $1.00 (=10*$0.10).

Example Payout 4: Suppose that round 9 is randomly chosen as the payout round. In round 9 you decided to speed, Regime B is instituted and you are caught speeding. Your payout for round 9 is $0.55. Therefore, your payout for rounds 1-10 is $5.50 (=10*$0.55).

Total Payouts: Your total payout is determined by summing your payouts for all thirty rounds, dividing this total in half, and then adding a $5.00 show up payment. The payout is mathematically explained below:

\[
Total \text{ Payout} = \frac{\sum_{i=1}^{30} Payout_i}{2} + 5
\]

Note that the minimum total payout that you could receive is $6.50 =($5.00+$1.50), which could be obtained by getting caught speeding in Regime A in all rounds. The maximum payout is $20.00 = ($5.00+$15.00), which could be obtained by speeding and not getting caught in all rounds.

Rounds 11-30: In each of the last 20 rounds you and the other members of the experiment will now have two decisions to make. First, you will vote on an enforcement regime and the regime receiving the majority vote will be posted so that everyone is aware of the enforcement regime. After observing the winning regime you will then be asked to decide whether you will speed or not. As in the first 10 rounds, an individual that speeds and arrives at the destination without being apprehended will receive a payout of $1.00 per round. An individual that speeds and is apprehended for speeding receives a payout of $1.00-$f per round, where f is the fine that is imposed by the enforcement regime that is instituted. Note that 0<f<1 always. Lastly, an individual that obeys the law and does not speed receives a payout of $0.60 per round.

Situation 1: Suppose 7 out of 11 people vote in favor of Regime A and so Regime A is instituted. An individual who chooses to speed has a one in three chance of being caught speeding and paying a fine of $0.90. There are three possible payouts that a participant could receive:
Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.10 (= $1.00-$0.90).

Situation 2: Suppose 6 out of 11 people vote in favor of Regime B and so Regime B is instituted. An individual who chooses to speed has a two in three chance of being caught speeding and paying a fine of $0.45. There are three possible payouts that a participant could receive:

Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.55 (= $1.00-$0.45).

Payouts: The payout that you will receive for rounds 1-10 will be determined by randomly choosing one of the 10 rounds and then multiplying the payout of that round by 10. Consider the following possible payouts:

Example Payout 1: Suppose that round 5 is randomly chosen as the payout round and that you decide to not speed in round 5 and so your payout for round 5 is $0.60. Therefore, your payout for rounds 1-10 is $6.00 (=10*$0.60).

Example Payout 2: Suppose that round 3 is randomly chosen as the payout round and that you decide to speed in round 3 and were not caught and so your payout for round 3 is $1.00. Therefore, your payout for rounds 1-10 is $10.00 (=10*$1.00).

Example Payout 3: Suppose that round 7 is randomly chosen as the payout round. In round 7 you decided to speed, Regime A is instituted and you are caught speeding. Your payout for round 7 is $0.10. Therefore, your payout for rounds 1-10 is $1.00 (=10*$0.10).

Example Payout 4: Suppose that round 9 is randomly chosen as the payout round. In round 9 you decided to speed, Regime B is instituted and you are caught speeding. Your payout for round 9 is $0.55. Therefore, your payout for rounds 1-10 is $5.50 (=10*$0.55).

Total Payouts: Your total payout is determined by summing your payouts for all thirty rounds, dividing this total in half, and then adding a $5.00 show up payment. The payout is mathematically explained below:

\[
Total \ Payout = \frac{\sum_{i=1}^{30} Payout_i}{2} + 5
\]

Note that the minimum total payout that you could receive is $6.50 = ($5.00+$1.50), which could be obtained by getting caught speeding in Regime A in all rounds. The maximum payout is $20.00 = ($5.00+$15.00), which could be obtained by speeding and not getting caught in all rounds.
Experiment Instructions – Setting 2

General Rules: No talking. No use of cell phones. No looking at neighbor's screens.

You are about to participate in an experiment on decision-making carried out by a graduate student researcher from the University of California at Santa Barbara. During this session, you can earn money. The amount of your earnings depends on your decisions and on the decisions of the other participants in this session. The session consists of 30 rounds. Your earnings will be determined by randomly choosing one payout from rounds 1-10, one payout from rounds 11-20, and one payout from rounds 21-30. The payout mechanism is explained in detail below. Your earnings will be paid to you in cash in private.

Your decisions are anonymous and confidential.

The experiment is split into 3 separate sections. Each section consists of 10 rounds. Instructions for each set of 10 rounds are provided below.

Rounds 1-10: You are attempting to travel to the same destination 10 separate times - much like a commuter travels to work every day - and will receive a payout for each separate trip. You will have the option to speed or not when traveling. There will be two potential enforcement regimes - which you will be told before deciding whether to speed or not - and the probability that either regime will be instituted is equally likely. An enforcement regime is both a probability of getting caught when speeding and a corresponding fine, denoted $f$, that will be imposed if you are caught speeding. An individual that speeds and arrives at the destination without being apprehended will receive a payout of $1.00 per round. An individual that speeds and is apprehended for speeding receives a payout of $1.00$-$f$ per round, where $f$ is the fine that is imposed by the enforcement regime that is instituted. Note that the fine is always positive and less than $1.00$. Lastly, an individual that obeys the law and does not speed receives a payout of $0.60$ per round.

Examples

There are two potential enforcement regimes:

Regime A: Chance of getting caught if speeding = 33%, Fine = $0.90

Regime B: Chance of getting caught if speeding = 66%, Fine = $0.45

Regime A and Regime B are equally likely - i.e. there is a 50% chance that either regime is randomly chosen.

Situation 1: Regime A is randomly selected. There are three possible payouts:
Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.10 (= $1.00-$0.90).

Situation 2: Regime B is randomly selected. There are three possible payouts:
Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.55 (= $1.00-$0.45).

Payouts: The payout that you will receive for rounds 1-10 will be determined by randomly choosing one of the 10 rounds and then multiplying the payout of that round by 10. Consider the following possible payouts:

Example Payout 1: Suppose that round 5 is randomly chosen as the payout round and that you had decided to not speed in round 5 and so your payout for round 5 is $0.60. Therefore, your payout for rounds 1-10 is $6.00 (=10*$0.60).

Example Payout 2: Suppose that round 3 is randomly chosen as the payout round and that you had decided to speed in round 3 and were not caught and so your payout for round 3 is $1.00. Therefore, your payout for rounds 1-10 is $10.00 (=10*$1.00).

Example Payout 3: Suppose that round 7 is randomly chosen as the payout round. In round 7 you had decided to speed, Regime A is instituted and you are caught speeding. Your payout for round 7 is $0.10. Therefore, your payout for rounds 1-10 is $1.00 (=10*$0.10).

Example Payout 4: Suppose that round 9 is randomly chosen as the payout round. In round 9 you had decided to speed, Regime B is instituted and you are caught speeding. Your payout for round 9 is $0.55. Therefore, your payout for rounds 1-10 is $5.50 (=10*$0.55).

Total Payouts: Your total payout is determined by summing your payouts for all thirty rounds, dividing this total in half, and then adding a $5.00 show up payment. The payout is mathematically explained below:

$$Total\ Payout = \frac{\sum_{i}^{30} Payout_i}{2} + 5$$

Note that the minimum total payout that you could receive is $6.50 =($5.00+$1.50), which could be obtained by getting caught speeding in Regime A in all rounds. The maximum payout is $20.00 = ($5.00+$15.00), which could be obtained by speeding and not getting caught in all rounds.

Rounds 11-20: As in the first ten rounds, you are attempting to travel to the same destination 10 separate times - much like a commuter travels to work every day - and will receive a payout for each separate trip. You will have the option to speed or not when traveling. The main difference between the rounds 1-10 and rounds 11-20 is that you will be told which regime is in place before deciding whether to speed or not. In other words, you will know with certainty the enforcement regime that is in place. Recall that an enforcement regime is both a probability of getting caught when speeding and a corresponding fine, denoted $f$, that will be imposed if you are caught speeding. An individual that speeds and arrives at the destination without being apprehended will receive a payout of $1.00 per round. An individual that speeds and is apprehended for speeding receives a payout of $1.00-$f per round, where $f$ is the fine that is imposed by the enforcement regime that is instituted. Note that $0<f<1$ always. Lastly, an individual that obeys the law and does not speed receives a payout of $0.60 per round.
Rounds 21-30: In each of the last 20 rounds you and the other members of the experiment will now have two decisions to make. First, you will vote on an enforcement regime and the regime receiving the majority vote will be posted so that everyone is aware of the enforcement regime. After observing the winning regime you will then be asked to decide whether you will speed or not. As in the first 10 rounds, an individual that speeds and arrives at the destination without being apprehended will receive a payout of $1.00 per round. An individual that speeds and is apprehended for speeding receives a payout of $1.00-$f per round, where f is the fine that is imposed by the enforcement regime that is instituted. Note that 0<f<1 always. Lastly, an individual that obeys the law and does not speed receives a payout of $0.60 per round.

Situation 1: Suppose 7 out of 11 people vote in favor of Regime A and so Regime A is instituted. An individual who chooses to speed has a one in three chance of being caught speeding and paying a fine of $0.90. There are three possible payouts that a participant could receive:

Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.10 (= $1.00-$0.90).

Situation 2: Suppose 6 out of 11 people vote in favor of Regime B and so Regime B is instituted. An individual who chooses to speed has a two in three chance of being caught speeding and paying a fine of $0.45. There are three possible payouts that a participant could receive:

Payout 1: Participant does not speed and receives a payout of $0.60.
Payout 2: Participant speeds, is not caught and receives a payout of $1.00.
Payout 3: Participant speeds, is caught and receives a payout of $0.55 (= $1.00-$0.45).

Payouts: The payout that you will receive for rounds 1-10 will be determined by randomly choosing one of the 10 rounds and then multiplying the payout of that round by 10. Consider the following possible payouts:

Example Payout 1: Suppose that round 5 is randomly chosen as the payout round and that you had decided to not speed in round 5 and so your payout for round 5 is $0.60. Therefore, your payout for rounds 1-10 is $6.00 (=10*$0.60).

Example Payout 2: Suppose that round 3 is randomly chosen as the payout round and that you had decided to speed in round 3 and were not caught and so your payout for round 3 is $1.00. Therefore, your payout for rounds 1-10 is $10.00 (=10*$1.00).

Example Payout 3: Suppose that round 7 is randomly chosen as the payout round. In round 7 you had decided to speed, Regime A is instituted and you are caught speeding. Your payout for round 7 is $0.10. Therefore, your payout for rounds 1-10 is $1.00 (=10*$0.10).

Example Payout 4: Suppose that round 9 is randomly chosen as the payout round. In round 9 you decided to speed, Regime B is instituted and you are caught speeding. Your payout for round 9 is $0.55. Therefore, your payout for rounds 1-10 is $5.50 (=10*$0.55).

Total Payouts: Your total payout is determined by summing your payouts for all thirty rounds, dividing this total in half, and then adding a $5.00 show up payment. The payout is mathematically explained below:
Total Payout = \frac{\sum_{i=1}^{30} \text{Payout}_i}{2} + 5

Note that the minimum total payout that you could receive is $6.50 = ($5.00 + $1.50), which could be obtained by getting caught speeding in Regime A in all rounds. The maximum payout is $20.00 = ($5.00 + $15.00), which could be obtained by speeding and not getting caught in all rounds.