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An empirical analysis of driver perceptions of the relationship between speed limits and safety

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A B S T R A C T

In recent decades, it has become more common for speed limits to be set for political reasons rather than for safety reasons. As a consequence, the motoring public seems to have increasingly begun questioning the rationality of speed limits. This is evident in observed speed data that show that the majority of drivers routinely exceed posted speed limits. A key motivating factor in drivers' tendency to exceed the speed limit is that they believe that the excess speed does not threaten safety. This paper, specifically studies this matter by using a survey that asked drivers how fast above the speed limit they feel they can drive before safety is threatened. A probabilistic model is estimated using data gathered from 988 drivers in Indiana. Estimation findings show that drivers' perception of the speed above the speed limit at which they will receive a speeding ticket is a critical determinant of what they believe is a safe speed – suggesting that enforcement plays an important role in safety perceptions. Other variables found to be significant factors in determining the speed above the speed limit at which safety is first threatened include age, gender, being previously stopped for speeding, and drivers' ethnicity.

1. Introduction

Public perceptions and respect for speed limits have been a concern of highway engineers since the earliest days of designing and constructing roadways for motorized vehicles. Highway engineers have long argued that speed limits should be closely tied to safety considerations to ensure respect and compliance, and that if speed limits are determined on the basis of other considerations (such as political considerations), a general disrespect for speed limits would likely result. A classic example of this was the passage of 1974's Emergency Highway Energy Conservation Act in the US, which mandated a 55 mph (89 km/h) national maximum speed limit on interstate highways. The fear of highway engineers at the time was that such an unrealistically low speed limit on interstate highways, which were designed for 70 mph (112 km/h), would erode respect for speed limits on all highways and potentially have a net adverse impact on highway safety.

In reflecting on the impact of the US's 55 mph national speed limit on interstate highways, most studies have concluded that the lower 55 mph speed limits did save lives (Farmer, Retting, & Lund, 1999; Kockelman & Bottom, 2006; National Highway Traffic Safety Administration, 1992). Although some have argued that the net effect of the 55 mph may be ambiguous or even detrimental to safety for a number of reasons including: a general lessened respect for speed limits; sub-optimal shifts

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in law enforcement resources in the wake of the 55 mph mandate; the possibility that the 55 mph speed limit moved riskier drivers away from interstates to inherently more dangerous non-interstate highways; and the possibility that the 55 mph speed limit increased speed variances and thus the likelihood of more crashes (see Lave & Elias, 1994; McCarthy, 2001).

Subsequent US legislation, such as the National Highway System Designation Act of 1995, has given states complete freedom to set interstate speed limits. Still, one has to question the long-term effects that the use of political considerations to set speed limits has on respect for speed limits and perceived safety. This is not necessarily an easy question to answer in light of how drivers' tastes for speed and evaluation of risk evolve over time in response to changing socioeconomics, vehicle safety features, societal values and so on. However, for whatever reason, respect for speed limits seems to have deteriorated in recent decades. A 2002 survey indicated that two-thirds of all drivers reported that they exceeded the posted speed limit and roughly one-third reported driving 10 mph (16 km/h) faster than most other vehicles (Royal, 2004). These figures are even more disturbing when one considers they are self-reported and likely to be understating the degree of the speeding problem. Actual observed data show that only about 5% of drivers operate at or below speed limits on interstate highway segments posted at 55 mph, and that as few as 23% of drivers operate at or below the posted speed limit on non-freeway facilities (National Highway Cooperative Research Program, 2003).

Drivers' decision to speed has been a worldwide focus of countless research efforts and these studies have provided significant insight into speed-related decision-making processes. As an example, Kanellaidis, Golias, and Zarifopoulos (1995) studied Greek drivers and found that drivers who believed that speed limits could reduce accidents were much more likely to comply with speed limits in general. They also found that speed limit compliance increased as drivers became older and decreased as the number of miles driven increased and as drivers' education level increased.

There have also been those studies that have viewed the tendency to speed as an outgrowth of underlying social and behavioral causes. Gabany, Plummer, and Grigg (1997) found that drivers' perceptions and attitudes toward speeding can be segmented into five predisposing, enabling and reinforcing constructs: ego gratification; risk-taking; time pressures; disdain of driving; and inattention. They found that gender and other socioeconomic factors were excellent mechanisms for defining these five segments. The work of Warner and Aberg (2006) studied the tendency to speed as an outgrowth of attitudes toward speeding, subjective norms regarding speeding, perceived behavioral control, self-reported speeding. Based on a survey from 122 test drivers they used structural equations modeling to determine the effect of these four factors on actual recorded speeds. Their subsequent research (Warner & Aberg, 2008) showed that indices constructed with the direct measures of attitude, subjective norm and perceived behavioral control are critical to the prediction of drivers' intention to exceed the speed.

In other work, Letirand and Delhomme (2005) looked at drivers' options of observing or exceeding speed limits in relation to the theory of planned behavior. Their findings show that the intention to exceed the speed limit can be predicted with reasonable accuracy by considering driver attitudes, subjective norms and perceived behavioral control. Interestingly, in this work it was found that only 8% of young male drivers reported observing the speed limit. The persistence of drivers' speeding problem was further studied by Delhomme, Grenier, and Kreel (2008) with regard to the effectiveness of driver rehabilitation courses (used to rehabilitate habitual traffic-regulation offenders) on speed-limit compliance. They found that only 38% of the drivers in the rehabilitation courses would actually commit to comply to speed limits in the future.

Other studies have focused on the effect of various law enforcement levels and speed-limit compliance (de Ward & Rooijers, 1994; Vaa, 1997) and conclusively demonstrated that increased enforcement significantly reduced the average speeds and the number of drivers exceeding the speed limit. Vaa (1997) also studied the enforcement "halo effect" (the suppression of speeds for some time after enforcement was discontinued), finding it significantly reduced speeds for as long as several weeks after enforcement was discontinued.

Studies also have shown a disconnect between what drivers consider to be speeding and their prospects of being caught for speeding. For example, Jorgensen and Pedersen (2005) found that, while drivers generally overestimated the probability of being caught speeding, older drivers had a better estimate of the speeding detection rate than their younger counterparts.

Perceptions of drivers' own speed and the speeds of others have also been shown to be unrealistic. As an example, Walton and Bathhurst (1998) found that more than 85% of drivers claimed to drive slower than the average driver. And, in a study of Swedish drivers, Haglund and Aberg (2000) found that drivers estimated that over 50% of other drivers exceeded the speed limit by more than 10 km/h, while actual data show that less than 23% of all drivers exceeded the speed limit by that amount.

The extant literature clearly shows that the general disrespect for speed limits is a widespread behavioral problem. From highway engineering and design principles we know that, in the absence of political influence, speed limits are set based on safety-related factors such as sight distance, stopping distances and prevailing traffic conditions (see Mannering, Washburn, & Kilareski, 2009). If all speed limits were set using these rational design-safety principles, certainly one would still expect some variation in compliance based on individual driver risk preferences and behavior. However, when one adds the fact that some speed limits can be set for political reasons (thus departing from the fundamental design-safety principles), the disjoint between speed limits and safety can cause a serious compliance problem.

In recognition of the growing problem of speed-limit compliance, a project was undertaken in Indiana's Tippecanoe County in 2004–05 to assess the potential effectiveness of "rational" speed limits (speed limits set solely on the basis of agency policies relating to design speed, traffic and safety principles). The logic being that if speed limits were set in a rational manner and properly enforced, compliance and safety would be improved. As part of this project, to assess perceptions of the relationship between speed limits and safety, an initial survey was distributed to drivers at the County's Bureau of Motor Vehicle branches that, along with information on travel characteristics, socioeconomics, and other factors, asked the question "At what point do you feel speeding becomes a threat to the personal safety of you and your family?" with allowable discrete responses being: 5 mph (8 km/h) over the speed limit; 10 mph (16 km/h) over the speed limit; and 20 mph (32 km/h) over the speed limit.[1] After this initial survey, speed limits were carefully set on eight roadway segments in the County (in accordance to highway agency policies relating to design speed, traffic and safety principles) and a media campaign to stress the dangers of speeding was undertaken (this campaign included radio and newspaper messages). A follow up survey was then conducted at the County's Bureau of Motor Vehicle branches to assess the effects of rational speed limits and the media campaign on drivers' assessment of the relationship between speed limits and safety. While the effect of correctly setting the speed limits on eight roadway segments (an extremely small portion of the County's total roadway mileage) was not expected to have a significant influence on speed limit-safety perceptions, it is possible that the influence of the media campaign could be significant.

The intent of this paper is to statistically assess drivers' perception of the relationship between speed limits and safety by studying how fast they feel they can drive above the speed limit before safety is threatened (the possible influence of the "rational" speed limits and media campaign on this perception will also be statistically tested). Understanding the factors that determine drivers' perception of speed limits and safety in this context can hopefully provide some new insights into the influence of speed limits on drivers' speed choice.

2. Methodology

Because the response data are ordered from lower to higher speeds (safety is not threatened until 5 mph (8 km/h), 10 mph (16 km/h), or 20 mph (32 km/h) over the speed limit), a model that accounts for such ordering, such as an ordered logit or probit model, would be an obvious first choice. However, various attempts to account for ordering in the data (including the estimation of ordered logit and probit models) all produced statistically disappointing results. This is likely due to the fact that ordered models place a restriction on variable effects in that they do not allow for the possibility of variables simultaneously decreasing or simultaneously increasing the "low" and "high" categories (see recent discussions in the literature on this by Gkritza, Niemeier, & Mannering, 2006; Islam & Mannering, 2006; Eluru, Bhat, & Hensher, 2008). This restriction can be unrealistic if there are, for example, driver attributes that make them more likely to choose the 10 mph-over category and simultaneously less likely to choose 5- and 20 mph-over categories.

Given the estimation problems encountered with modeling the data as ordered, an unordered discrete choice approach was adopted. This is done by defining a function that determines safety-threatening speed (the speed above the speed limit that safety is first threatened) as

$$S_{in} = \boldsymbol{\beta}_i \boldsymbol{X}_{in} + \varepsilon_{in}, \tag{1}$$

where S_{in} is the function that determines the probability of discrete-speed category i for driver n, $\boldsymbol{X}_{in}$ is a vector of measurable characteristics (socioeconomics and driver perceptions) that determine the discrete-speed category for driver n, $\boldsymbol{\beta}_i$ is a vector of estimable parameters, and ε_{in} is an error term accounting for unobserved effects influencing the choice speed above the speed limit that is perceived to produce a safety risk.

It can be shown that if ε_{in} is assumed to be extreme value distributed (McFadden, 1981), then a standard multinomial logit model results

$$P_n(i) = \frac{\mathrm{EXP}[\boldsymbol{\beta}_i \boldsymbol{X}_{in}]}{\sum_{\forall I} \mathrm{EXP}(\beta_I \boldsymbol{X}_{In})}, \tag{2}$$

where $P_n(i)$ is the probability that driver n will perceive a safety risk for the "speed above the speed limit" category i and I is the set of possible categories (5, 10 or 20 mph over the speed limit).

Elasticities can be used to assess the magnitude of the impact of specific variables on the outcome probabilities. The elasticity is computed for each driver n (n subscripting omitted) as

$$E_{x_{ki}}^{P(i)} = \frac{\partial P(i)}{\partial x_{ki}} \times \frac{x_{ki}}{P(i)}, \tag{3}$$

where $P(i)$ is the probability of a driver choosing speed category i and x_{ki} is the value of variable k (with subscript k defining individual variables in the vector $\boldsymbol{X}$) for speed category i. Using Eqs. (2) and (3) gives

$$E_{x_{ki}}^{P(i)} = [1 - P(i)]\beta_{ki} x_{ki}, \tag{4}$$

where β_{ki} is the estimated parameter associated with variable x_{ki}. Elasticity values can be roughly interpreted as the percent effect that a 1% change in x_{ki} has on the speed-category probability $P(i)$.

Note that elasticities are not applicable to indicator variables (those variables taking on values of 0 or 1). In these cases, a pseudo-elasticity can be calculated in percent as

$$E_{x_{ki}}^{P(i)} = \left[\frac{\mathrm{EXP}[\Delta(\beta_i \boldsymbol{X}_i)] \sum_{\forall I} \mathrm{EXP}(\beta_{kI} x_{kI})}{\mathrm{EXP}[\Delta(\boldsymbol{\beta}_i \boldsymbol{X}_i)] \sum_{\forall I_j} \mathrm{EXP}(\beta_{kI} x_{kI}) + \sum_{\forall I \neq I_j} \mathrm{EXP}(\beta_{kI} x_{kI})} - 1 \right] \times 100, \tag{5}$$

[1] A fourth option "speeding is not a threat" was also provided but too few people chose this alternative to have it considered in the statistical analysis.

where I_j is the set of speed-over-the-speed-limit categories with x_k in the function determining the speed categories, and I is the set of all possible speed categories. The pseudo-elasticity of a variable with respect to a speed category represents the percent change in the probability of that speed category when the variable x_{ki} is changed from zero to one. Thus, a pseudo-elasticity of 95% for a variable in the "5 mph over the speed limit" category means that when the value of the variable in the sub-set of observations where $x_{ki} = 0$ is changed from 0 to 1, the probabilities of the "5 mph over the speed limit" category for these observations increased, on average, by 95%.

Cross elasticities are also of interest to determine the net effect of variables that may be found significant in more than one function determining discrete-outcome choice (more than one R_{in}, see Eq. (1)). The cross elasticity provides the effect that a change in a variable influencing choice j has on the probability of some other choice i. The equation for this in the standard multinomial logit structure is

$$E_{x_{kj}}^{P(i)} = P(j)\beta_{kj}x_{kj}. \tag{6}$$

Please see Washington, Karlaftis, and Mannering (2003) for a complete explanation of elasticities.

3. Data

As discussed in Section 1, data were collected in two waves: one wave before the setting of rational speed limits and the media campaign and one after. Information from a total of 1334 drivers was obtained (646 observations before the rational speed limits and media campaign, and 688 after). The survey collected a variety of information relating to drivers' driving records and vehicle usage, as well as perceptions of speed limits, their perceived risk of being ticketed for speeding and their perceived decline in safety as they exceeded the speed limit. Also, a variety of socioeconomic information was gathered including gender, age, years licensed as a driver, and race/ethnicity.

With regard to the question being studied, the data indicated that, 292 (22%) of the respondents thought speeding was a threat to safety at 5 mph over the speed limit; 550 (41%) thought it was a threat at 10 mph over; 437 (33%) thought it was a threat at 20 mph over; 28 (2%) did not think speeding was a threat and 27 (2%) did not answer. As previously mentioned, because the percent of those that did not think speed was a threat to safety was so small, the sample was limited to those people that answered the question indicating speeding was a threat at 5, 10 or 20 mph over the speed limit. The sample was further reduced to include only drivers with complete information, resulting in 988 valid observations. Summary statistics for this reduced sample are presented in Table 1.

Table 1 shows that, in the final sample of 988 drivers, 21% thought the safety-threatening speed was 5 mph over the speed limit, 43% thought the safety-threatening speed was 10 mph over the speed limit, and 36% thought the safety-threatening speed was 20 mph over the speed limit. On average, drivers did not think they would get a speeding ticket until they drove 6.76 mph (10.88 km/h) over the speed limit. This suggests that drivers seem to have some expectation of leniency. It is also noteworthy that 71% of the drivers in the sample report that they had been stopped for speeding at some point in their driving history. Finally, Table 1 shows that the general socioeconomic characteristics (age, gender, and race) are roughly in line with the overall Indiana driving population.

4. Estimation results

Multinomial logit estimation results are presented in Table 2. Recall that the data were collected in two waves, one before the rational speed on eight roadway segments and media campaign to stress the dangers of speeding, and one after.

Table 1
Selected driver sample statistics

Variable	Values
Percent male/female	47/53
Percent licensed at age 17 or later	36
Percent: White/African American/Hispanic/Asian/Other	86/2/6/3/3
Average age in years (standard deviation in parentheses)	41.13 (15.03)
Average number of years licensed (standard deviation in parentheses)	23.49 (14.72)
Percent believing personal safety is threatened at: 5 mph over the speed limit/ 10 mph over the speed limit/20 mph over the speed limit	21/44/35
Type of vehicle driven most often (in percent): passenger car/pickup truck/minivan or van/sport utility vehicle/other	54/17/12/15/2
Percent driving: almost every day/a few days per week/a few days per month, year or never	93/6/1
Percent driving (on days that they drive): less than 20 miles a day/20 to 50 miles a day/more than 50 miles per day	51/40/9
How much over the speed limit can you drive before police usually give a ticket (average in mph, standard deviation in parentheses)	6.76 (4.55)
Since licensed, percent having been stopped for speeding/never stopped	71/29
Percent ticketed the last time they were stopped for speeding	41
Percent indicating that the last time they were stopped for speeding they were going over the speed limit by 1–9/10–14/15–19/20 mph or more	25/49/19/7
Percent indicating that they saw or heard something about the dangers of speeding in the past 3 months	68
Percent indicating that when they see or hear reports of the dangers of speeding it has some effect on their driving	62

Table 2
Multinomial logit model estimation results of the probability of drivers believing personal safety is threatened at 5 mph over the speed limit, 10 mph over the speed limit or 20 mph over the speed limit

Variable	Estimated coefficient	*t*-Ratio
Constant [5]	0.481	2.27
Driver perceptions		
How much over the speed limit can you drive before police usually give a ticket (in mph) [5]	−0.386	−10.58
How much over the speed limit can you drive before police usually give a ticket (in mph) [10]	−0.102	−6.00
Driver socioeconomics		
Male (1 if male, 0 otherwise) [10]	−0.398	−2.94
Female, never stopped for speeding (1 if female and never stopped for speeding, 0 otherwise) [5]	0.674	3.21
Stopped for speeding in the past year (1 if stopped for speeding in the past year, 0 otherwise) [20]	0.365	1.79
Driver age in years [20]	−0.029	−8.19
African American (1 if African American, 0 otherwise) [10]	−0.844	−1.98
Log-likelihood at zero	−1085.4	
Log-likelihood at convergence	−933.3	
Number of observations	988	

Variables are defined for outcomes: [5] 5 mph over the speed limit, [10] 10 mph over the speed limit, and [20] 20 mph over the speed limit.

Table 3
Computed elasticities

Variable	Elasticity
Driver perceptions	
How much over the speed limit can you drive before police usually give a ticket (in mph) [5]	−1.97[a,c]
How much over the speed limit can you drive before police usually give a ticket (in mph) [10]	−0.06[a,c]
How much over the speed limit can you drive before police usually give a ticket (in mph) [20] (computed from cross-elasticities)	0.63[a,c]
Driver socioeconomics	
Male (1 if male, 0 otherwise) [10]	−96.0[b]
Female, never stopped for speeding (1 if female and never stopped for speeding, 0 otherwise) [5]	68.2[b]
Stopped for speeding in the past year (1 if stopped for speeding in the past year, 0 otherwise) [20]	25.4[b]
Driver age in years [20]	−0.75[a]
African American (1 if African American, 0 otherwise) [10]	−44.3[b]

Elasticities are defined for outcomes: [5] 5 mph over the speed limit, [10] 10 mph over the speed limit, and [20] 20 mph over the speed limit.
[a] Because this "speed over the speed limit" variable is active for choice alternatives [5] and [10], computed elasticity values consider the net effect of this variable on choice probabilities by accounting for cross elasticities (see text and Washington et al. (2003)).
[b] Indicator variable. Value gives the effect of that changing the variable from zero to one has on the selection probability in percent (see text).
[c] Continuous variables. Value roughly interpreted as the effect that a 1% change in the variable will have on the outcome selection probability (in percent, see text).

To test if the rational speeds and the media campaign had an influence on the speeds at which drivers believe safety is threatened, separate models were estimated using the before and after data, and a likelihood ratio test was conducted. The appropriate likelihood ratio test is $-2[\mathrm{LL}(\beta_T) - \mathrm{LL}(\beta_b) - \mathrm{LL}(\beta_a)]$ where $\mathrm{LL}(\beta_T)$ is the log-likelihood at convergence of the model estimated with before and after data; $\mathrm{LL}(\beta_b)$ is the log-likelihood at convergence of the model estimated with only before data; and $\mathrm{LL}(\beta_a)$ is the log-likelihood at convergence of the model estimated with only after data. This statistic is χ^2 distributed with degrees of freedom equal to the number of estimated parameters in the model (9 in this case as shown in Table 2). In this case, the resulting χ^2 statistic is 11.0 and, with 9 degrees of freedom, the hypothesis that the before and after models are the same cannot be rejected even at a very modest 75% confidence level. Thus, a single model of the data is used.

In general, the model fits the data well (especially considering the variance in the data) and the parameter estimates are of plausible sign and generally good statistical reliability.[2] To assess the effect of variables on the speed category selection probabilities, elasticities (averaged over the driver population) are presented in Table 3.

[2] To test for the validity of the multinomial logit structure, different nested logit structures were estimated but, in all cases, these structures reduced to the multinomial logit structure – indicating that it is the appropriate structure. To allow for possible variations in parameter estimates across the population, mixed logit models were also estimated using a variety of distributional assumptions for the parameter variations. In all cases, the assumption that the parameters were fixed across the population could not be rejected, again supporting the chosen model structure. See Washington et al. (2003), Train (2003), and Milton, Shankar, and Mannering (2008) for discussions and example applications of these alternate modeling structures.

Turning to specific findings, drivers' perceptions of the speed above the speed limit at which they believe they will receive a ticket (perceived-ticket speed) has a strongly significant impact on their assessment of safety risk.[3] Elasticity results in Table 3 show on average that a 1% increase in perceived-ticket speed results in a 1.97% reduction in their probability of thinking the safety-threatening speed is 5 mph above the speed limit. For the 10 mph category, a 1% increase in the perceived-ticket speed results in only a 0.06% reduction in the probability of a safety-threatening speed of 10 mph above the speed limit. The net effect of these (computed from cross-elasticities) is that a 1% increase in the perceived-ticket speed results in a 0.63% increase in their thinking that the safety-threatening speed is 20 mph above the speed limit. These findings show that drivers are linking perceptions of safety to the likelihood of being ticketed – possibly reflecting the belief that officers will ticket only when safety is threatened.

In other findings, men were found to be less likely to believe that the category of driving 10 mph above the speed limit was the point at which safety was threatened. With a t-statistic of -3.50, this highly statistically significant result shows that men have a dichotomy of being more likely to believe the safety-threatening speed is either 5 or 20 mph over the speed limit (a finding that supports the unordered model structure as previously discussed).

Female drivers that have never been stopped for speeding (roughly 39% of all female drivers) were found to be about 68% more likely to believe the safety-threatening speed is 5 mph over the speed limit. Here, a strong correlation between reported behavior (reflected in speeding stops) and perceptions of safety is clearly evident.

Drivers that have been stopped for speeding in the last year were found to be about 25% more likely to believe the safety-threatening speed is 20 miles per hour over the speed limit. Again, as was the case for female drivers that were never stopped for speeding, this variable is likely capturing the perceptions of safety and risk of these individuals (reflected in speeding stops).

As expected, as driver age increased, the probability of believing that safety-threatening speed is 20 mph above the speed limit decreased (thus increasing the probabilities of believing the safety-threatening speed is 5 mph and 10 mph over the speed limit). Elasticity computations (see Table 3) show that roughly a 1% increase age had a 0.75% decrease in the probability of the "20 mph over the speed limit category" being selected. This likely reflects the more conservative and safety-cautious attitudes associated with older drivers.

Finally African American respondents were found to be less likely to believe the safety-threatening speed was 10 mph over the speed limit. African American respondents were roughly 44% less likely to believe the safety-threatening speed was 10 mph over the speed limit. This variable is most likely capturing unobserved heterogeneity (possibly relating to socioeconomic factors not collected in the survey such as incomes, family size, and so on) that just happens to be correlated with this ethnicity indicator variable.

With regard to the overall effect of the media, respondents in both survey waves were asked if they had seen or heard any media messages about the dangers of speeding in the past 3 months, and if such messages affected their driving. Data from the pre-media campaign respondents showed that 61% reported hearing about the dangers of speeding with 63% indicating such messages had (or would have) some effect on their driving. For the post-media campaign respondents, 74% reported hearing about the dangers of speeding with 60% indicating such messages had (or would have) some effect on their driving. However, when one statistically accounts for the fact that the safest drivers are more likely to report hearing about and responding to media messages about the dangers of speeding, these two variables were found to be statistically insignificant when included in the model.[4]

5. Discussion

In assessing the estimation results provided in this paper, at least three points are worthy of mention. First, the survey data were limited in that only a local sample of Indiana drivers was used and thus the transferability of these findings to other geographic areas could not be studied. Second, the survey question studied "At what point do you feel speeding becomes a threat to the personal safety of you and your family?" is somewhat limiting in that one could imagine a series of questions along these lines that could be used to control potential biases. For example, asking: at what speed you feel your driving becomes a threat; and at what speed do you feel others' driving becomes a threat could be used to uncover interesting perceptual differences.

[3] To informally test whether this variable is endogenous (whether the speed you believe safety is threatened affects your opinion as to when you will receive a speeding ticket), a regression of the speed above the speed limit at which you will first be ticketed was estimated on all exogenous variables. These regression-estimated speeds were then used as independent variables in the model. When this is done, the findings did not change significantly and thus actual reported speeds were used for this variable. This test is informal because using such an instrumental variables approach in a logit model does not strictly correct endogeneity as it does in ordinary least squares estimation, although empirical studies have shown an instrumental variables approach produces near-correct parameter estimates (Abrevaya, 2008).

[4] Because drivers report that safety is threatened at lower speeds may also be more likely to report hearing about and responding to media messages about the dangers of speeding, these variables must be considered endogenous in model estimation. To approximate this effect, separate binary logit models were estimated for the probability of hearing media messages concerning speeding and the probability that these media messages will affect one's driving. These estimated probabilities are then used as independent variables in the model. When this is done, the estimated parameters of these variables were found to be statistically insignificant from zero suggesting that such media messages do not have a significant effect on the perceived safety-threatening speed. As discussed in the footnote 3, this is an informal procedure because using such an instrumental variables approach in a logit model does not strictly correct endogeneity (Abrevaya, 2008).

The third point relates to the use of discrete intervals (5, 10, and 20 mph) over the speed limit (as opposed to a continuous variable) and the ordinal nature of the data. The statistical assessment of the data showed clearly that unordered models produced significantly better statistical fits relative to models that accounted for the ordinal nature of the data. This suggests that there are variables that simultaneously increase (or decrease) the low- and high-speed values. The estimation results show that this was the case for males and African American drivers, both of which were more likely to be in the 5 and 20 mph over categories (and thus less likely to be in the 10 mph over the speed limit category). This finding is not likely to be an artifact of the modeling approach used because ordered probability models, nested logit and mixed logit models (both generalized forms of the multinomial logit model presented in Table 2) were estimated to confirm the appropriateness of the multinomial logit results. Thus, in this case, the linear–variable relationship assumption that would be imposed by standard ordered models is simply not appropriate and can lead to biased parameter estimates. In fact, the potential problems with using standard ordered models on ordered discrete data has been the subject of a number of recent papers (see Eluru et al., 2008; Yamamoto, Hashiji, & Shankar, 2008), and this needs to be given careful consideration in future research in the area of speed limit compliance.

Among the findings of this research, the finding that drivers' perception of how much they can drive over the speed limit before getting a ticket has a large impact on their speed-safety perception is noteworthy, as is its high elasticity (a 1% increase in the speed drivers believe they will get a ticket decreases their likelihood of thinking safety is threatened at just 5 mph over the speed limit by nearly 2%). Other notable findings relate to gender effects, age effects (older drivers are more likely to think safety is threatened before 20 mph over the speed limit), and ethnic effects.

The results of this study add to the extensive and growing body of literature on speed limits and speed-limit compliance. With continual changes in vehicle safety technologies and driver responses to such technologies, as well as driver attitudes toward speed limits and changes in speed-limit setting policies, drivers' perceptions of the relationship between speed limits and safety is dynamic and promising area for further research.

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