



A structural analysis of U.S. drunk driving policy



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ABSTRACT

The expected penalty for drunk driving can and does vary by blood alcohol content. This paper outlines the schedule of penalties that best achieves two key social objectives, efficacy and efficiency (subject to constraints), shows how the associated optimality conditions can be implemented with available data to analyze policy ex ante or ex post, and then uses these findings to assess four fundamental features of current U.S. drunk driving policy. Large penalties at very high alcohol concentrations are supported, but not reductions in per se blood alcohol thresholds, the most significant recent change in policy.

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1. Introduction

This paper introduces a theoretically-grounded, structural method for evaluating drunk driving policy, which treats the law as a menu, or schedule, of expected penalties associated with different blood alcohol concentrations (BACs). The optimal schedule of penalties, or “penalty structure,” is characterized with simple equations that can be evaluated with epidemiological and economic data. Deviations from optimality suggest beneficial changes in policy. While this has not been previously attempted for drunk driving, similar methods have fruitfully analyzed the widely-used “points system,” whereby a driver’s license is suspended after he tallies a specified number of points for traffic law violations within a given time period (Bourgeon and Picard, 2007; Dionne et al., 2011).

Methodologically, one could not draw a greater contrast with the traditional way of analyzing drunk driving policy, “reduced form” regressions relating traffic fatalities to law variables and controls. The two approaches complement each other in several respects.

Our approach is prospective where traditional methods are retrospective. They depend on data on past outcomes. Often, because of differences in sample and technique, the literature on the effects of any given law does not converge until long after the law has been widely implemented, by which time the decision window on

that policy may have closed (Grant, 2013). Our approach, in contrast, utilizes behavioral primitives that, we show, are stable across time. It can thus evaluate policy before it has been implemented anywhere.

While traditional methods estimate the effects of policy, ours examines the economic influences underlying those effects. The intellectual cornerstone of U.S. drunk driving policy is deterrence theory: drivers are rational actors who will respond purposively to disincentives for driving drunk. (For example, the drunk driving countermeasures promoted by the National Highway Traffic Safety Administration, or NHTSA, are heavily weighted toward deterrence, as are those most studied by economists.) Our approach can determine if regression-estimated behavioral responses so conform, looking inside the “black box” of deterrence, in the process reinforcing some studies’ findings while contradicting others.

Finally, while traditional methods focus on the effects of specific laws, ours takes the broad view, examining general features of policy in light of various social objectives. As severely impaired drivers are far more dangerous than moderate drinkers, an improved penalty structure could significantly impact alcohol-related traffic safety, where U.S. progress has been scant for fifteen years, during which the rate of alcohol involvement in fatal accidents has not budged.

In fact, our analysis finds significant deviations from optimality. These support one major recent policy thrust, increasing penalties at high BACs, but not another, lowering illegal BAC thresholds. The analysis also supports appropriate Congressional initiatives

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that promote policy uniformity, but not those that have mandated different treatment for youth and adults.

2. Theory

Based on the work of Kenkel (1993a, 1993b, 1996), we abstract from the resource costs of imposing punishment, which are second order, and from the production and service of alcohol, as these markets are sufficiently competitive that any changes in prices or profits resulting from policy changes should be short lived.¹ We also abstract from the extensive margin – loosely speaking, the level of penalties – to focus instead on the intensive margin, how penalties rise with BAC. The former has been adequately studied by Kenkel (1993a, 1993b), who finds that penalties are inefficiently low.

Following Kenkel and the tenets of deterrence theory, each driver is assumed to maximize utility, taking into account alcohol costs and expected penalties,² and internalizing only his own expected accident costs, ignoring those imposed on others. The driver must balance the consumer surplus from drinking with the penalties he may receive from driving afterwards. The latter is represented by $S(c)$, the expected value (or opportunity cost) of any penalties that may be received for driving drunk, expressed as a function of blood alcohol concentration, c . The former is represented by the function $V_i(c)$, the private “value” of drinking and driving. To conform with S , it too is expressed in terms of c , and thus represents the amount driver i would be willing to pay, in the absence of penalties, to be able to purchase enough alcohol to achieve a given BAC. This will vary across individuals because of variation in preferences, the price paid for alcohol, and the rate at which alcohol increases individuals’ BAC. For our purposes it suffices to subsume all of this into V .

The driver’s privately optimal consumption level, c^* , maximizes $V-S$. In the absence of penalties, this sets $V'=0$. In the presence of penalties, however, each driver curtails his consumption until $V'=S'$. Table 1 defines all variables used in this paper and lists the data source from which each is measured.

2.1. Efficiency

If the objective were economic efficiency, a social planner would determine each driver’s consumption, c_i , $i = 1, N$, in order to maximize total surplus:

$$\max_{c_1 \dots c_N} \sum_{i=1}^N V_i(c_i) - X(c_i) \tag{1}$$

¹ These papers also abstract from the supply side. In Kenkel’s (1993b) simulation of the effects of stricter deterrence policies, the additional resource costs required are \$63 billion, while the value of the reduced death and injury, based on Kenkel (1993a), is over fifty times greater.

Punishment is implicitly assumed to involve transfers (fines) rather than dead-weight losses (license suspensions or jail), which are never efficient. But the optimality condition below holds if a constant fraction (in c) of penalties are dead-weight losses, which is reasonably accurate.

² This assumes drivers respond “rationally” to the disincentives provided by the law. While standard in economics, this is not likely to be strictly true here. For example, people modestly misperceive the chances of arrest and of having an accident with injury (Dionne et al., 2007), and respond more to the certainty of punishment than its severity (for an application to drunk driving, see Grosvenor et al., 1999). Nonetheless, it is probably a reasonable approximation. Sloan, Eldred, and Xu’s (2014) survey data indicates that drunk drivers are more impulsive and present-oriented than the average person, but also (p. 77) that “persons who frequently drink and drive...know what they are doing and understand the legal consequences of their behavior.” Hansen (2013) argues that these deterrence effects dominate other potential causal links between drunk driving laws and traffic safety, incapacitation and rehabilitation.

where $X(c)$ represents each driver’s expected external accident costs, assumed as a simplifying assumption to be the same for all drivers. The familiar optimality condition, $V_i' = X'$, is achieved when the policymaker sets $S' = X'$ for all c . This is the standard Pigovian tax that forces agents to internalize external costs. Were S and X measured in dollars, one could assess policy efficiency directly by seeing if this equivalence holds in practice at each value of c .

While S and X can be proxied, however, this is not easily done in dollar terms: several values that would be required to do so, such as the costs imposed by license revocation or the fraction of accident costs that should be considered external, are not precisely known. Fortunately, for our purposes we can use a weaker condition, necessary though not sufficient for efficiency, that lets S and X be measured in arbitrary units. This “cost-effectiveness” condition, analogous to the equi-marginal principle in production theory, requires only that drunk driving damages be decreased at the least “cost” to consumers—that is, the smallest aggregate reduction in V . The social planner thus solves:

$$\max_{c_1 \dots c_N} \sum_{i=1}^N V_i(c_i) \quad \text{subject to} \quad \sum_{i=1}^N X(c_i) = \Phi \tag{2}$$

with Φ an arbitrary scalar. The optimality condition $V_i' = \lambda X'$, with $\lambda(\Phi)$ the scalar Lagrange multiplier on the constraint, is to be met for, at least, all $c_i \geq \underline{c}$, where \underline{c} is the minimum BAC level for which there is a per se drunk driving violation—typically 0.08 g/dl. The policymaker can achieve this result by setting $S' = \lambda X'$ for all $c \geq \underline{c}$. Then X'/S' should be constant over this domain but the value of the constant need not be specified. When this ratio is not constant, an equal reduction in external damages can be obtained at less aggregate inconvenience to drinking drivers, by raising the marginal penalty at BAC levels where this ratio is large and lowering it where this ratio is small.

Putting this ratio into logarithms yields a unitless cost-effectiveness optimality condition:

$$\log(X') - \log(S') = \kappa \quad \forall c > \underline{c} \tag{3}$$

with κ a constant whose value is meaningful only when S and X are measured in identical units: then positive (negative) κ implies an inefficiently low (high) penalty. Note that any multiple kS^{CE} of a cost-effective penalty structure S^{CE} is also cost-effective: the extensive and intensive margins are separated. Given data on S and X , the left hand side of this condition can be evaluated at each value of c . If the resulting values are constant, optimality obtains; otherwise, the deviations from optimality suggest how policy can be improved.

2.2. Efficacy

The efficiency standard is potentially problematic in that it gives drunk drivers “standing” in the cost-benefit analysis that underlies policy design (see Trumbull, 1990; Kenkel, 1998). This may run counter to society’s intention in branding the drunk driver a criminal. According to this perspective, drunk driving is not an externality problem, but a question of rights, and a per se illegal drunk driving BAC threshold may be construed as a point at which the individual no longer has the right to use public roads.³

³ The most recent extended Congressional debate on drunk driving policy, on a 1998 bill impelling the states to adopt a .08 per se illegal BAC limit for adult drivers, adopted just this perspective. It ignored the “cost” on which efficiency hinges, consumer surplus lost by reduced alcohol consumption among heavy drinking-drivers, focusing instead on social drinkers’ right to consume modest amounts of alcohol and drive, and citizens’ right to drive on safe roads (see Congressional Record 144, no. 19–20, 3–4 March 1998:S1236–S1305). A similar perspective emerges from Rodriguez-Iglesias, Wiliszowski, and Lacey’s (2001) study of the legislative history of state 0.08 laws.

Table 1
Variables of interest and data sources.

Variable Name	Variable Type	Symbol	Variable Description	Data Source	Year and Location
Consumer Preferences	Primitive	$V_i(c)$	The amount consumer i is willing to pay for permission to purchase c units of alcohol at the market price, drink them, and then drive	See text	National surveys spanning a variety of years
Driving Impairment	Primitive	$X(c)$	The expected, monetized external damages to life, health, and property generated by a driver who has consumed c units of alcohol	Blomberg et al. (2009)	Long Beach, CA, and Fort Lauderdale, FL; 1997–1999
Drunk Driving Penalty Structure	Policy	$S(c)$	The expected, monetized value of the legal penalties incurred from driving after consuming c units of alcohol	Beitel et al. (1975)	Kansas City, MO; 1973
Realized Alcohol Consumption	Market-wide outcome	$F_c(c)$	The number (technically, density) of drivers possessing c units of alcohol in their blood	Calculated using FARS	All states; 1988–2000
Realized Fatal Accidents	Market-wide outcome	$A(c)$	The number (technically, density) of fatal crashes involving drivers who have consumed c units of alcohol	FARS	All states; 1988–2000

Note: All expectations are unconditional—that is, per driver or per trip, not per arrest or accident.

This suggests an alternate objective, efficacy: minimizing drunk driving fatalities within this framework of rights, and the implicit eighth amendment right that punishment not be excessive. Accordingly, return to the program in Eq. (2) take the dual, set the weight on V to zero for all $c \geq \underline{c}$, and add the constraint that S must never exceed S_{MAX} , the penalty maximum. The problem facing the policymaker now becomes:

$$\min_S \sum_{i=1}^N X(c_i^*) \quad \text{subject to } S(c) = 0 \text{ for } c < \underline{c},$$

$$0 \leq S(c) \leq S_{MAX} \quad \text{for } c \geq \underline{c} \quad (4)$$

where each driver's c^* satisfies $V' = S'$, as before. This framework has not trivialized the problem. Fig. 1 below suggests that

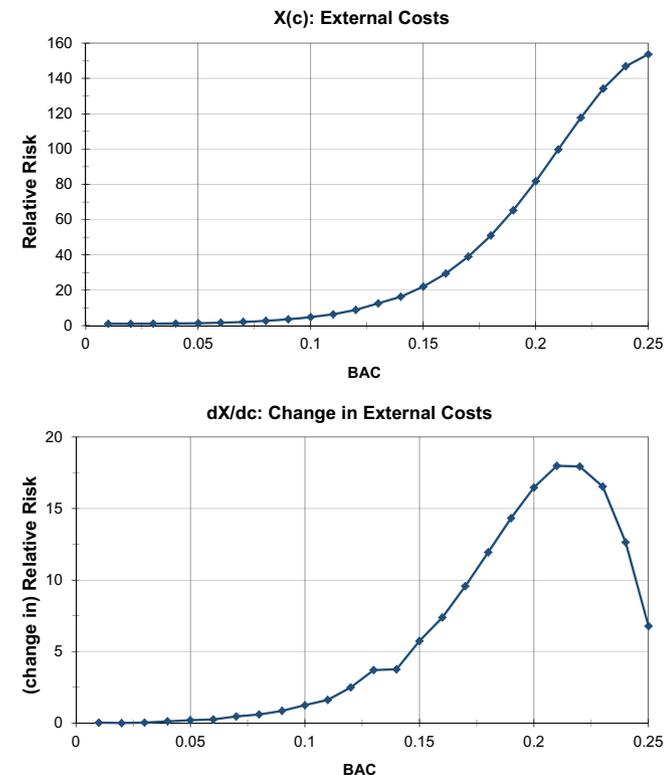


Fig. 1. Physiological Relationship between alcohol consumption and crash probability.

drinking-imposed impairment roughly plateaus for $c \geq 0.25$. Optimality implies the maximum penalty S_{MAX} will be imposed at this BAC level, labeled c_{max} , but not necessarily below it. Rather, marginal (expected) penalties usually will be “parceled out” across the entire domain $[\underline{c}, c_{max}]$.

The “expediency” condition that shows how this is best done is most easily derived in terms of these marginal penalties. Let $M_{.08}$ be the expected marginal penalty associated with having $c = .08$ rather than $c = .07$, and $M_{.09}, M_{.10}$, etc., be defined accordingly; thus $S(.10) = M_{.08} + M_{.09} + M_{.10}$, and so on. The policymaker’s program is now:

$$\min_{M_{.08}, M_{.09}, \dots, M_{c_{max}}} \sum_{i=1}^N X(c_i^*) \quad \text{subject to } \sum_{c=.08}^{c_{max}} M_c \leq S_{MAX} \quad (5)$$

Taking the derivative with respect to $M_{.08}, M_{.09}$, etc., yields a set of first order conditions associated with optimal policy. Appropriately rearranged, these can be combined into:

$$\hat{\lambda} = \sum_{i=1}^N X'_i \frac{\partial c_i^*}{\partial M_c} \approx X' F_c(c) \overline{\frac{\partial c^*}{\partial M_c}} \quad \forall \underline{c} < c < c_{max} \quad (6)$$

where $\hat{\lambda}(S_{MAX})$ is a Lagrange multiplier, F_c is the density of c^* across the population of drivers, and the average is taken across all drivers affected by the policy at that value of c . The marginal effect of a unit increase in marginal penalties is the product of the number of drivers affected, the average change in their consumption, and the rate at which this change reduces external costs. Barring a corner solution, optimality implies these marginal effects should be equal for all $c > \underline{c}$. If they are not, drunk driving damages could be decreased by simply rearranging the penalty structure, holding S_{MAX} constant. Given the socio-political constraints limiting the severity of penalties that can be imposed, policy changes save lives if, and only if, they are expedient.

Again taking logarithms yields the following unitless “expediency” optimality condition:

$$\log(X') + \log(F_c) + \log(\overline{\partial c^* / \partial M}) = \hat{\kappa} \quad \forall \underline{c} < c < c_{max} \quad (7)$$

with $\hat{\kappa}$ again an arbitrary constant. If the left-hand side of this equation, when evaluated, is not constant in c , then penalties should be strengthened (weakened) where its values are largest (smallest).

With expediency, unlike cost-effectiveness, the magnitude of penalties (indexed by S_{MAX}) and the shape of the penalty structure are intertwined. Consider a sequence of penalty structures associated with increasing values of S_{MAX} . As these penalties are enacted, some drivers will drink less, so F_c falls at higher values of c and

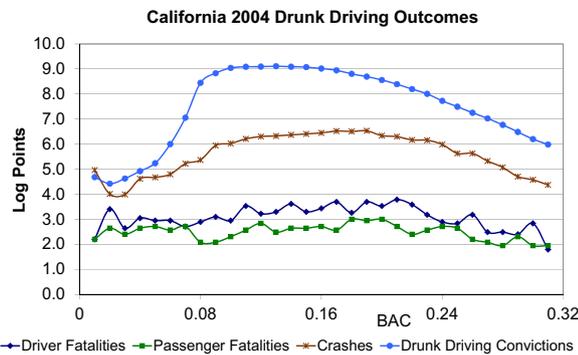


Fig. 2. Drunk driving outcomes for California, 2004. Note: Fatalities come from FARS, described in the text, and the other variables from Tashima and Daoud (2007). Drunk driving convictions include DUI and alcohol-related reckless driving convictions. All variables are annual aggregates for the year 2004, logged.

grows at lower values of c . Consequently, following the expediency condition, the next penalty structure in the sequence focuses more on milder drinkers. This evolution is broadly consistent with the reduction in BAC thresholds observed in the U.S. as drunk driving sanctions have become more forceful. In the extreme, as in Scandinavia, draconian penalties are applied at low BACs, which few drinkers exceed.

The expediency and cost-effectiveness conditions, though distinct, do not diverge. Increasing marginal penalties at \hat{c} will reduce $F_c(\hat{c})$, so both conditions will take smaller values. While existing policy might be more closely aligned with expediency than cost-effectiveness, or vice versa, similar policy adjustments could be justified under both.

3. Data

To evaluate our optimality conditions, Eqs. (3) and (7), X' , F_c , $\partial c^*/\partial M$, and M must be measured for all feasible BACs for which driving is outlawed, which, as a practical matter, given the limits of our data, is [0.08,0.25]. As all variables are logged, the units of measurement do not matter.

External costs, X , are taken from Blomberg et al.'s (2009) exhaustive study of 15,000 drivers in Florida and California. Using the standard case-control epidemiological method, relative crash probabilities were determined for each 0.01 unit of BAC, adjusted for driver demographics, accident characteristics, and (using supplemental data) various data collection problems. The final estimates are quite precise—the error variance is dwarfed by the variation of the risks themselves.

Fig. 1 presents X , the crash risk relative to a non-drinker (whose value is one), and its difference, $X(c) - X(c - 0.01) \approx X'$. Relative risks increase at an increasing rate, rising dramatically above 0.10 and even more dramatically near 0.20, until reaching a plateau around 0.25. At this point the relative risk is over one hundred times that of drivers with BACs under the 0.08 per se limit.

The evidence indicates these crash risks are reasonable proxies for economic costs. In a nationwide study, Blincoe et al. (2002) find that the average economic costs of mild-drinkers' and heavy-drinkers' accidents are comparable.⁴ Crash risks are also a reasonable proxy for external costs. Fig. 2 identifies the

⁴ In this study, a BAC level of 0.10 separates mild and heavy drinkers. Heavy-drinkers' accidents are more likely to involve severe or fatal injuries (which generate half of all economic costs), but are also more likely to have no injuries whatsoever. The former is very costly but rare, the latter common but not costly. On balance, the two offset: the average economic cost of a crash involving a drinking driver with BAC below (above) 0.10 is slightly above (below) \$20,000 (Tables 13 and 14).

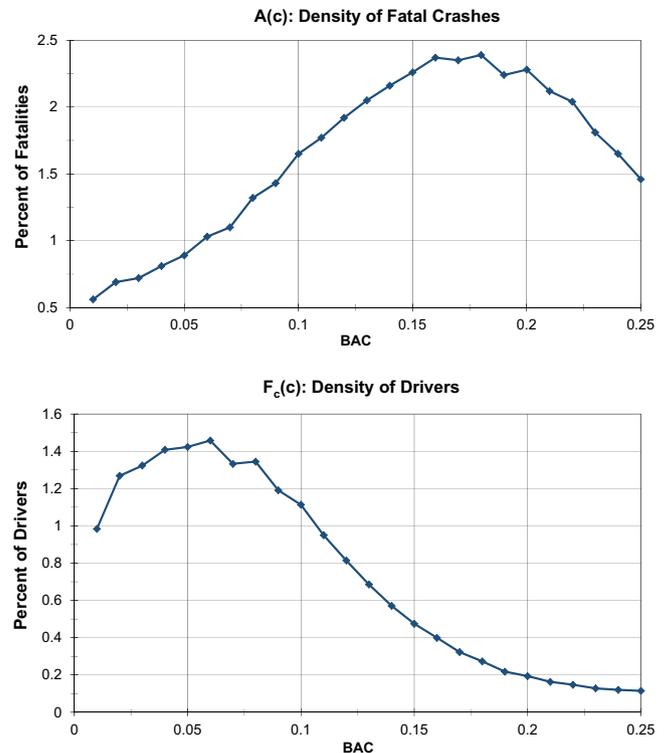


Fig. 3. Distribution of fatal crashes and imputed distribution of drivers by BAC level.

number of crashes, driver fatalities, and passenger fatalities by BAC for California in 2004 (the only such data we could find). For BACs of 0.08 or more, the three variables differ by roughly the same number of log points—that is, they are roughly proportional.

The second term, F_c , cannot be directly observed but can be calculated, as the number of accidents at a given BAC equals the product of the number of drivers and crash risk. Fig. 3 presents the density of accidents, A , taken from NHTSA's Fatality Analysis Reporting System (FARS),⁵ and the implied density of driver BAC, $F_c \propto A/X$.⁶ The prevalence of heavy drinkers in fatal crashes, long emphasized by NHTSA, is apparent. Because of their greatly elevated crash risk, heavy drinkers comprise a much smaller fraction of all drivers.

The third term, $\partial c^*/\partial M$, measures the responsiveness of consumption to penalties. The relevant studies are not numerous or precise enough to quantify this numerically, but a general trend runs through the literature. For increases in the drinking age, Carpenter et al. (2007, Tables 2 and 3) and Keng and Huffman (2007) find similar reductions in consumption among mild and heavy drinkers. For zero tolerance laws, Wagenaar et al.

⁵ This is a census of all fatal crashes on U.S. public roads. Driver BAC is measured directly in about half of the observations and is imputed using NHTSA's imputation technique for the others, mostly nondrinkers (Subramanian and Utter, 1998). Only about 5% of the observations involve drinking drivers with unmeasured BAC. Fatalities were tabulated for single-vehicle crashes only, for which accident responsibility is clear, but over the .08–0.25 BAC range, the results were almost identical if all fatalities in multi-vehicle crashes were assigned to the highest BAC among all drivers involved (roughly consistent with Levitt and Porter, 2001).

⁶ The geographic and temporal span of the data over which A is calculated reflects a tradeoff between precision, logical consistency, and national representativeness. A longer sample increases reduces "sampling error," but also reflects an amalgam of traffic safety policies as different states adopt different laws at different times. Erring on the side of inclusiveness, A is tabulated for all states for the years 1988–2000. This period of relative policy stability postdates the increase in the drinking age and mostly predates the widespread enactment of 0.08 per se limits and aggravated drunk driving laws (McCartt, 2001). As A is not adjusted for demographics, a similarly unadjusted version of X , also from Blomberg et al. (2009), was used in calculating F_c .

(2001) find similar reductions in mild drinking and heavy drinking, and similar reductions in driving after drinking for both groups. Carpenter (2004) found greater reductions in heavy drinking than overall drinking and no change in drunk driving conditional on drinking, while heavy drinking falls somewhat less than drinking participation in Carpenter et al. (2007, Tables 2 and 3). For 0.08 laws, the point estimates in Carpenter and Harris (2005, Table 4), though imprecise, find larger responses among “medium” than mild drinkers, with mixed findings for heavy drinkers. Benson et al. (1999) and Eisenberg (2003) examine how these and several other laws influence fatalities involving drinkers and heavy drinkers; generally the effects are comparable. Collectively these studies suggest mild and heavy drinkers respond to legal incentives in roughly equal measure.⁷ For simplicity we assume that $\partial c^*/\partial M$ is constant for all c .

The final variable, S , is the monetary equivalent of the expected drunk driving penalty. Except for aggravated drunk driving laws, which explicitly raise penalties at higher BACs, this is roughly proportional to the probability of being arrested for drunk driving (see Perrine et al., 1988).⁸ Initially we ignore aggravated drunk driving laws and set S equal to this probability, taken from the classic source, Beitel et al. (1975).⁹ Later we relax this restriction and explicitly account for the raised penalties in aggravated drunk driving laws.

Both S and $S(c) - S(c - 0.01) \approx S' \equiv M$ are presented in Fig. 4. Both increase substantially at all BAC levels above 0.08; the risk of arrest is ten times higher at 0.20, a sizeable difference but much smaller than the relative crash risks illustrated above. While the optimality condition involving S is based not on levels, but rates of change, these too grow much more slowly for arrests than for fatalities. Increases in M , at the bottom of Fig. 4, do not keep pace with increases in X' .

⁷ They also respond similarly to price incentives. Several studies of drinking among young adults collectively show absolute declines in consumption, in response to price increases, that are at least as large among heavy drinkers as among light or moderate drinkers (Chaloupka et al., 2002; Wagenaar et al., 2009). Manning et al. (1995) and Kenkel (1996) find the overall price elasticity of heavy drinkers to be roughly half that of moderate drinkers, which also implies similar absolute changes in consumption, as heavy drinkers consume much more alcohol on average. Saffer et al. (2012) break down their estimates across nine quantiles of drinking intensity and achieve a similar result. Finally, Farrell et al. (2003) find a substantial price elasticity of heavy drinking that seems to exceed that for drinking generally, while Shrestha (2015) shows that, among youth, price elasticities are largest for heavy drinkers. Unfortunately, analogous evidence on the price elasticity of drunk driving among different types of drinkers is not available.

⁸ Kenkel (1993b) sets out S as the product of P_A , the probability of arrest; P_C , the probability of conviction if arrested; L , the monetized penalty if convicted; and a discount factor $(1+r)^{-T}$, where r is the discount rate and T the interval between crime and punishment.

Given the short interval – months, not years – between arrest and sentencing, however, discounting should be minimal, so the last term can be ignored. The second and third are effectively constant in c . Conviction rates, P_C , diminish slightly at higher BACs in Hansen’s (2013) recent data from Washington, but remain uniformly high throughout the relevant BAC range. Assessing L , the actual penalties conditional on conviction (as opposed to minima or maxima), is complicated by limited data and the wide variety of penalties that can be imposed. Nonetheless, in California, Tashima (1986) finds that these penalties increase only slightly at BACs exceeding 0.20; since then Tashima reports that “sanctions have become much more homogeneous for [drunk driving] offenders.” In Washington, Hansen (2013) finds that many penalties, such as the incidence of probation and alcohol treatment, are relatively constant in BAC, but others, such as jail time, are not. Most of the variation in these latter penalties occurs at that state’s aggravated drunk driving threshold, 0.15. Similarly, Zador et al.’s (2000) national data indicates that fines are relatively constant in BAC, but for a jump at 0.15 that is presumably associated with aggravated drunk driving laws.

⁹ Based on a field experiment in Kansas City in 1973, this study calculates the conditional probability of arrest, in 0.05 BAC unit increments (0.01–0.05, etc.), from the unconditional probability of arrest in the field experiment and survey evidence on the BACs of drivers who were, and were not, arrested for drunk driving. This was converted to 0.01 increments by fitting a cubic spline to the data.

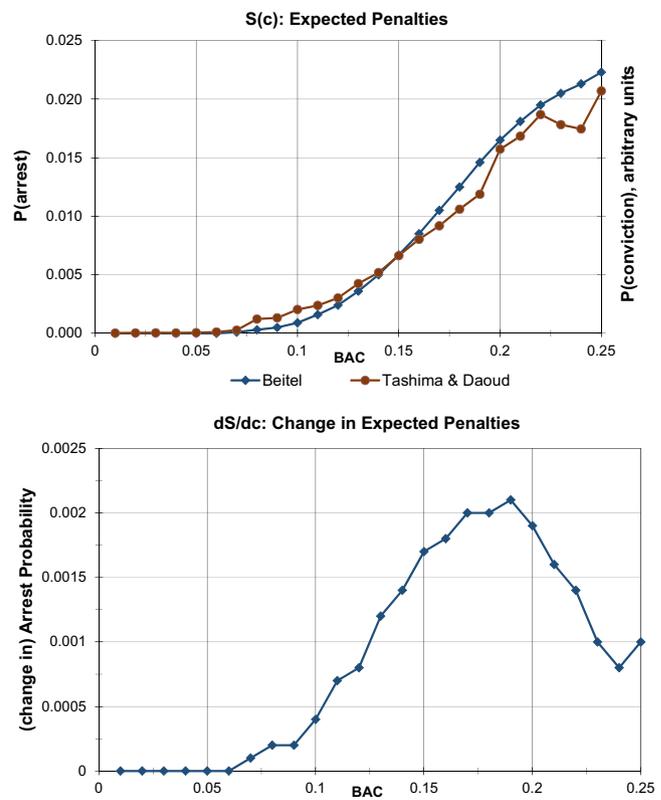


Fig. 4. Relationship between alcohol consumption and expected legal penalties.

3.1. Stability

The data for S and X may not be nationally representative, and the S data is not recent. How much this matters depends on the spatial and temporal stability of these variables. Such stability will be present if their values derive from a physiological response to inebriation that generates driving behaviors that cause accidents or attract the notice of police (see NHTSA, 1998a), and will be absent if their values are sensitive to safety attitudes, road conditions, etc., that vary across time and space. If the former dominates, estimates of S and X from one place or time should apply to others, and the policy relevance of our analysis is enhanced.

The evidence unanimously suggests this is the case. Similar estimates for S are obtained by Hause et al. (1982), in California. The X values used here are modestly, but not vastly, higher than the nationally representative estimates obtained by Levitt and Porter (2001) with a much different estimation approach (which does not calculate X for 0.01 BAC increments). And our inferred F_c (which is a function of X) resembles that in Beitel et al. (1975).

A final check utilizes the crash and drunk driving conviction variables in Fig. 2. The former and X determine F_c ; this and convictions determine the probability of being convicted for drunk driving conditional on c . This alternative measure of S , found in Fig. 4, is based on modern data from California and Florida, not older data from Kansas City. It nevertheless closely resembles the original, suggesting our key variables are, indeed, reasonably stable.¹⁰

¹⁰ The issue of stability is not eliminated by analyzing drunk driving policy using a reduced form approach. It is just more easily overlooked. In these studies, it is common to assume or assert that the future effects of a drunk driving policy in new jurisdictions will resemble the estimates of that policy’s past effects in its original jurisdiction. This implicitly invokes stability of the underlying primitives. The present analysis indicates that this is, in fact, a reasonable thing to do.

4. Results

4.1. Basic results

Figs. 1–4 show that the greatest variation in key variables occurs at BACs far beyond the current threshold of 0.08. The greatest variation in our optimality conditions also occurs there.

Fig. 5 graphs the cost-effectiveness condition, Eq. (3), over the BAC range of interest, scaled to zero at $c=0.10$. This can be interpreted either as the logged ratio of marginal external costs to marginal penalties, or (because consumption satisfies $V' = S'$) as the logged ratio of marginal external costs to the consumer surplus lost from a one unit reduction in driver BAC. Cost-effectiveness is lowest at BACs below 0.15 and increases steadily thereafter, to a maximum of 1.5 log points, a five-fold difference. By this standard, policy is far too heavily weighted toward drivers with BACs under 0.15. Welfare gains from penalty decreases here would more than offset losses from penalty increases elsewhere, keeping total external costs the same.

Fig. 5 also illustrates the expediency condition, Eq. (7), over the same BAC range. Each point of this figure depicts, again in arbitrary, logged units scaled to zero at $BAC=0.10$, the reduction in external costs obtained by a one-unit increase in marginal penalties at that BAC value. Larger values are therefore more expedient than smaller values. This condition, too, is smallest at moderate BACs, below 0.12, rising rapidly above that point until falling again beyond 0.20. The gap between maximum and minimum, about one log point, is again sizeable. Fatalities could be substantially reduced by increasing marginal penalties where expediency is largest and lowering them, in equal measure, where it is smallest.

Is current policy more consistent with cost-effectiveness or expediency? As the values and shapes of the two conditions are so

similar, it is not easy to choose. For the U.S., at least, their similarities are more noteworthy than their differences.¹¹

4.2. Policy analysis

We now use these conditions to analyze four features of U.S. drunk driving policy.

4.2.1. Lower BAC thresholds

All states have lowered the illegal per se BAC threshold for adults from 0.10 to 0.08 (and the National Transportation Safety Board has recommended a further reduction, to 0.05). How does this affect cost-effectiveness and expediency?

The movement from 0.10 to 0.08 increases marginal penalties, S' , in the neighborhood of 0.08 and decreases them near 0.10. For this change to improve either, the value of the condition must be falling over the 0.08–0.11 BAC range, meriting stronger penalties at lower end of this range, where cost-effectiveness and expediency would be highest. But in Fig. 5 cost-effectiveness is roughly constant over this range, while expediency is rising. The implication of this result is striking: lowering BAC thresholds from 0.10 to 0.08 should not reduce traffic fatalities, and might increase them. As marginal penalties are shifted downward heavier drinkers relax their efforts to comply with the law, and this outweighs the effect of reduced consumption from the milder drinkers who do comply.

The “common-sense” conclusion that lower limits reduce fatalities would be supported by the expediency condition if drinking closely adhered to the original limit to begin with. In those circumstances, with an initial limit of 0.10, drivers would bunch at BACs of 0.07–0.09, in conformity with the law. Then F_c and A would take large values at those BACs, and low values at 0.10 and 0.11, and the expediency condition would be falling, not rising, over the 0.07–0.11 range. Reducing the limit to 0.08 should then push many of these drivers' BAC down further, reducing fatalities. But Fig. 3 shows that such bunching does not occur, so reductions in that threshold are not productive.

The absence of bunching intimates that we should consider the expected penalties embodied in existing law to have a relatively mild deterrent effect. A scale analysis suggests that this is true, at least, in relative terms: under conservative assumptions, expected internal accident costs dwarf expected penalties.¹² If this is accurate, then marginal penalties should focus on drivers with high BACs.

4.2.2. Youth vs. adults

Throughout the 1980s and 1990s states adopted lower BAC thresholds for drivers under twenty-one, so called zero tolerance laws. Is this supported by expediency or cost-effectiveness? Are other differences in the penalty structure between youth and adults so justified?

Efficiency-based age differences in drunk driving penalties can be justified by differences in marginal crash risks, X' . These clearly exist. Zador et al. (2000) find crash risks are twice as high for youth as for adults at all BAC levels studied, so $X'_{YOUTH}(c) \approx 2X'_{ADULT}(c)$.

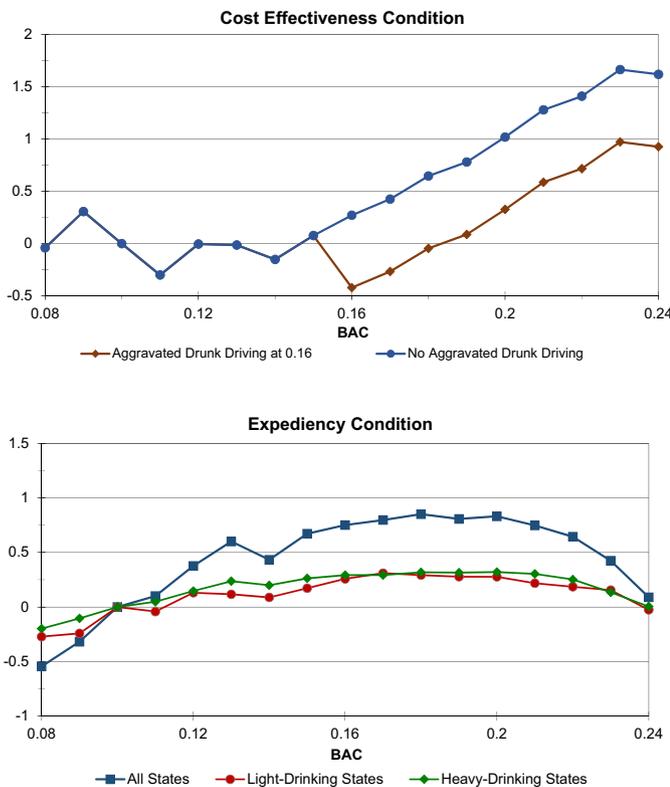


Fig. 5. Cost-effectiveness condition and expediency condition. Note: The expediency condition is flatter for the two subgroups of states because these groups' drinking is more homogenous than it is for all states together.

¹¹ This need not be surprising. When $\overline{\partial c^+ / \partial M}$ is constant across BAC levels, the two conditions imply equivalent penalty structures if F_c is inversely proportional to M . A comparison of Figs. 3 and 4 shows that this is basically true, at least until BAC exceeds 0.20.

¹² Expected own-accident costs exceed expected penalties by a factor of three under the following assumptions: (1) the cost of a driver fatality is \$4,000,000 (a conservative figure for the value of a statistical life); (2) the expected cost of an arrest is \$10,000 (consistent, in current dollars, with Kenkel, 1993b, and higher than Levitt and Porter, 2001); and (3) there are about 7000 fatalities of drivers with a BAC of at least 0.08 and one million drunk driving arrests annually (from FARS and the Sourcebook of Criminal Justice Statistics).

This proportionality implies the youth and adult penalty structures should have similar shapes but different magnitudes. Current policy has the opposite features: different shapes, because the BAC thresholds differ, but similar magnitudes once the threshold is violated.

Expediency also implies the adult and youth penalty structures should be similarly shaped. In addition to X , this depends on $\frac{\partial c^*}{\partial M}$. The studies cited above suggest the rough constancy of $\frac{\partial c^*}{\partial M}$ applies for both youth and adults, while our analysis of the FARS data indicates that the distribution of drivers, F_c , for positive BACs is also proportional between youth and adults. Thus, as with lower BAC thresholds for adults, zero tolerance laws for youth should not reduce drunk driving fatalities. Public safety is better advanced by focusing marginal penalties on young drivers with high BACs, even if penalties at very low BACs are permitted by the “rights” perspective discussed above.

4.2.3. Aggravated drunk driving laws

At least forty states currently have “aggravated drunk driving” statutes mandating additional penalties or reduced flexibility in adjudication or sentencing when the driver’s BAC exceeds a threshold that ranges from 0.15 to 0.20. The extra penalties range widely: South Dakota only requires pre-sentencing alcohol evaluations for $c \geq 0.17$, while Idaho requires ten days jail time and doubles the maximum fine and period of license suspension for $c \geq 0.20$. Several other countries also have similarly graduated penalties (NHTSA, 2000, 2001a).

In Fig. 5 we analyze the effect of a hypothetical aggravated drunk driving law, somewhat stronger than the median, that doubles penalties for BACs exceeding 0.15. Cost-effectiveness is dramatically improved—and would increase further with additional penalties for BACs over 0.20. These laws increase marginal penalties in the BAC region where increased penalties have the greatest ratio of benefits to costs. Because drunk driving penalties are inefficiently low (Kenkel, 1993a), economic efficiency increases as well.¹³

We cannot show exactly how aggregated drunk driving laws affect expediency without asserting how they will change the distribution of fatal accidents, which no study has attempted to do. Still, it is clear from Fig. 5 that expediency should also increase, as these laws operate in precisely the BAC range in which increased penalties most reduce external costs.

4.2.4. Uniformity of laws

A final feature of drunk driving policy is increased uniformity across the states, partly in response to Congressional incentives to enact 0.08 and zero tolerance laws. Cox (2006) has pointed out, however, that flexibility may be preferred to uniformity if there are sufficient differences in drinking behavior across the states. If the conditions for expedient policy vary systematically across states, then policy uniformity is not appropriate.¹⁴

¹³ Kenkel (1993a) argued aggravated drunk driving laws were probably unwarranted under an efficiency criterion because crash and arrest risks increased with BAC by similar proportions. The more recent, more detailed data on crash risks employed here indicate otherwise. Unlike their predecessors, Blomberg et al. (2009) track down about one-sixth of all hit-and-run drivers, who have very high BACs, and use passive alcohol sensors to impute the BAC of breath test refusals, who also have high BACs. Accounting for these problems increases the relative risk at a BAC of 0.20 threefold. This conclusion is reinforced with the California data reported in Fig. 2, where the ratio of drunk driving convictions to crashes (the difference in log points) diminishes steadily above a BAC of 0.08. The optimality conditions bring these differences into even sharper relief, as they are based on marginal changes in these variables, not levels.

¹⁴ The cost-effectiveness of uniform policy cannot be ascertained. This does not depend on F_c or A , only (possibly) on other factors w that influence traffic safety. When these factors increase the crash risk of all drivers by the same proportion, so

A natural comparison is between high-drinking and low-drinking states. In 2002, for example, the percentage of drivers involved in fatal accidents having a BAC of 0.08 or higher had a 0.90/0.10 decile range, across states, of 28% to 16%. Thus, Fig. 5 illustrates the expediency condition for the five states with the largest values of the aforementioned percentage and for the five with the smallest values. The two are strikingly similar: in this comparison, uniformity is supported (given the right policies, of course). Though alcohol involvement varies across states, the distribution of BAC conditional on drinking does not, to any appreciable degree, supporting policy uniformity.

4.3. Comparison with traditional methods

If our methods and data are sound, our findings should accord with those of traditional, reduced form studies of the same policy.

For the final two analyses, policy uniformity and aggravated drunk driving, such comparisons are not possible: there are no reduced form analyses to compare our findings with. Aggravated drunk driving does not lend itself easily to regression analysis, as these laws vary greatly in the BAC cutoff utilized and the type of penalty imposed (NHTSA, 2001a). Policy uniformity is even harder to study this way, as regressions can only establish what existing laws have done, not what alternatives might do, and would face practical difficulties precisely estimating laws’ effects along multiple dimensions.

For the initial two analyses, concerning 0.08 and zero tolerance laws, such comparisons are possible, but attention must be paid to study timing (see Grant, 2010, 2013). In both literatures, the largest effects, on the order of 15%, appear early on, when little post-law data is available for analysis and the analytical methods that are employed are relatively crude. (For 0.08 laws, see the studies cited in NHTSA, 1998b, 2001b and in General Accounting Office, 1999; for zero tolerance laws, see Blomberg, 2002; Hingson et al., 1994; Voas et al., 2003). Later studies, using much more post-law data and preferred panel methods, generally find much smaller effects. The findings of the most recent, comprehensive fatality analyses of each law are, indeed, consistent with our structural findings. For 0.08 laws, Freeman’s (2007) panel regressions obtain insignificant coefficients of both signs, while Young and Beilinska-Kwapisz’s (2006) estimates are insignificant or positive, suggesting that, if anything, these laws increase fatalities. For zero tolerance laws, the panel analyses of Dee et al. (2005), Grant (2010), and Anderson et al. (2013) all conclude that they have no effect on fatalities.

This all suggests a useful role for structural analysis as a check on, or corrective to, early studies of new drunk driving laws. For both 0.08 per se and zero tolerance laws, these relatively enthusiastic estimates supported successful Congressional incentives that spread this legislation nationwide, well before the academic literature could arrive at more modest estimates of its effects. Our methods offer a more timely way to examine the plausibility of these early studies’ findings.

5. Conclusions

Economics has typically viewed traffic safety policy in hindsight, through retrospective empirical studies of laws’ effects on traffic fatalities. Here, however, hindsight is not perfect: these studies are subject to the same estimation problems that plague economists elsewhere, and often generate conflicting or ambiguous results (Benson et al., 1999). Furthermore, such analyses are necessarily

that $X(w,c) = f(w)g(c)$, cost-effectiveness is identical across states, policy uniformity is appropriate, and Federal mandates to bring this about may be justified. One cannot determine whether this separability is genuine, but it is plausible.

limited to laws that are sufficiently widespread and longstanding that their effects can be precisely estimated. All this justifies considering an alternative approach not subject to these restrictions.

The complementary alternative proffered here simply sets out the conditions that characterize ideal policy and evaluates them with available data. This allows the whole of the penalty structure to be examined, for the first time, permitting both ex post analysis of existing policy or ex ante analysis of new policy proposals. Whether one adopts a traditional efficiency perspective or a politically-oriented expediency perspective, the implications are similar and the deviations from optimality large.

Our findings support applying greater marginal penalties to drivers vastly exceeding the current adult threshold of 0.08, whether they are youth or adults, and imply that optimal policies will be similar across states. Some laws have moved in this direction, such as aggravated drunk driving laws and federal incentives that promote uniform policy, but others have not. This may explain the 21st century stasis in alcohol involvement in U.S. traffic fatalities, despite legislation designed to lower BAC thresholds and drunk driving generally. The tools presented here can be used to evaluate future proposals in the quest for improved drunk driving countermeasures.

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