

# Punishment and Deterrence: Replication of Drunk Driving Study Using Cross-Validation

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## ABSTRACT

This study employs a regression discontinuity design (RDD) to evaluate the causal impact of DUI penalties on recidivism rates, specifically focusing on the legal blood alcohol content (BAC) thresholds. By isolating individuals slightly below and above the BAC cutoffs for regular and aggravated DUI offenses, the RDD approach allows for a clear observation of the causal effects of increased penalty severity on subsequent DUI incidents. By optimizing bandwidth selection through cross-validation, the replication addresses potential biases and variance errors, enhancing the model's ability to generalize findings across different samples. The initial results suggest that the additional sanctions experienced by drunk drivers at BAC thresholds are effective in reducing repeat drunk driving, while the replicated results indicate a more conservative estimate of the effect on recidivism.

## **I. Introduction**

Driving under the influence (DUI) remains a major public health and safety issue, contributing significantly to traffic-related fatalities. Historical data from the National Highway Traffic and Safety Administration indicates that since 1975, drunk driving has been involved in over half a million traffic fatalities, a number comparable to the homicides recorded over the same period. This alarming statistic highlights the severe societal impact of drunk driving, emphasizing its gravity alongside violent crimes.

In response, many states have implemented stricter DUI laws with tougher penalties, based on the principle that increasing the perceived costs of crime should deter potential offenders. This approach is grounded in the economic theory of crime introduced by Becker in 1968, which posits that if the expected costs of committing a crime exceed the benefits, individuals will be deterred from engaging in illegal activities. Supporting this theory, various studies have demonstrated that enhanced enforcement and stricter penalties can effectively reduce both minor and severe criminal activities, including traffic violations. This paper utilizes a robust analytical framework to examine the impact of increased DUI penalties on the likelihood of reoffending. Utilizing extensive data from 512,964 DUI stops in Washington state, the study employs a regression discontinuity design. This method exploits the precise Blood Alcohol Content (BAC) thresholds legally defined to differentiate between levels of DUI offenses. This quasi-experimental approach allows for an accurate assessment of the causal effects of penalty severity on repeat DUI incidents.

Moreover, the study incorporates cross-validation techniques to ensure the robustness and accuracy of its findings. This statistical method involves dividing the data into several subsets to test and validate the model's predictive power across different scenarios, optimizing the model's ability to generalize across varied data samples. Through cross-validation, the study fine-tunes the selection of bandwidth—the range of data around the threshold used for analysis. This is critical as it significantly influences the accuracy and reliability of the regression discontinuity analysis. The correct bandwidth choice helps mitigate issues of bias—where the model might overly simplify the relationship between variables—and variance—where the model might fit the data too closely and capture non-existent patterns. The integration of these methodologies in our

analysis aims to provide a comprehensive understanding of the deterrent effects of stricter DUI penalties. By offering detailed insights into how legal thresholds and subsequent punishments influence recidivist behavior, this paper seeks to contribute valuable recommendations for public policy aimed at enhancing road safety and reducing the prevalence of drunk driving.

## **II. Literature Review**

In our DUI recidivism study, we employ machine learning in conjunction with (RDD) to investigate the effects of legal sanctions, by integrating cross-validation techniques, specifically K-Fold, to ensure the reliability and generalizability of our models. This approach draws upon insights from the study "Impact of the Choice of Cross-Validation Techniques on the Results of Machine Learning-Based Diagnostic Applications," which highlights the significance of choosing appropriate cross-validation methods to maintain model integrity, especially in RDD contexts where treatment assignment hinges on a specific threshold, such as blood alcohol content. Cross-validation is essential in our research to prevent overfitting and to ensure that our models deliver consistent performance across different subsets of DUI data. The referenced study emphasizes the importance of using subject-wise cross-validation in settings with repeated measures from the same subjects, ensuring that the validation process mirrors clinical trial conditions and maintains the independence of training and test datasets. Adopting these robust cross-validation methods in our DUI study allows us to rigorously test the effectiveness of our predictive models on DUI sanctions. By doing so, we enhance the credibility of our findings and strengthen their applicability in formulating policy decisions related to DUI offenses, affirming the utility of scientifically grounded approaches in legal and behavioral studies.

## **III. Methodology**

This paper utilizes administrative records from DUI tests conducted in Washington State from 1995 to 2011 to examine the impact of punishments on drunk driving recidivism. Recidivism, as defined in this study, is the occurrence of a subsequent DUI offense within four years of the original offense, reflecting a realistic interval for offenders to reoffend post-suspension. Specifically, the study analyzes 512,964 DUI tests. The data allows for the use

of a regression discontinuity design (RDD) to explore how punishments based on Blood Alcohol Content (BAC) thresholds influence the probability of reoffending within a four-year window. A 4 year time frame was chosen to accommodate the typical duration of license suspensions. To implement machine learning in this study, we used cross-validation in a RDD context to ensure the robustness of machine learning models used to predict recidivism. By systematically dividing the dataset into multiple training and validation subsets, the study tests the stability and reliability of predictive outcomes across different samples, thereby enhancing the accuracy and generalizability of the machine learning models applied.

## IV. Results

**Table:** RDD Estimates for the Effect of DUI Penalties on Recidivism

Ind. Variable	Coefficient	Std Error	P-value
[0.025      0.975]			
Constant	5.4709	0.826	0.000
	3.851	7.091	
DUI	-0.0236	0.004	0.000
	-0.032	-0.015	
Agg. DUI	-0.0065	0.003	0.050
	-0.013	-2.6e-06	
Observations	90074		
R-squared	0.004		
bandwidth	0.05		

**Table:** Replicated RDD Estimates for the Effect of DUI Penalties on Recidivism

Ind. Variable	Coefficient	Std Error	P-value
[0.025      0.975]			
Constant	6.0302	1.093	0.000
	3.775	7.990	
DUI	-0.0158	0.006	0.005
	-0.027	-0.005	
Agg. Dui	-0.0037	0.004	0.388
	-0.012	0.005	
Observations	90074		
R-squared	0.005		
bandwidth	0.028		

The Regression Discontinuity Design (RDD) analysis presented in the report assesses the effects of DUI penalties on recidivism. The results indicate that DUI penalties have a statistically significant but modest effect on reducing recidivism rates. Specifically, the direct estimates show a reduction in recidivism with a coefficient of -0.0236 for DUI penalties, significant at a p-value of less than 0.001. The aggregated DUI penalties also suggest a reduction, though less pronounced, with a coefficient of -0.0065 and a marginal significance level (p-value = 0.050). The replicated study largely confirms these findings but with a slightly weaker effect, as evidenced by a DUI coefficient of -0.0158 (p-value = 0.005) and a non-significant coefficient for aggravated DUI penalties (p-value = 0.388). Both models exhibit very low R-squared values of 0.004 and 0.005 respectively, indicating that while the effects of DUI penalties are statistically significant, they account for a very small fraction of the variance in recidivism rates. This suggests that while stricter DUI penalties are associated with lower recidivism, their overall impact on recidivism is limited.

## **V. Discussion**

The study effectively bridges the empirical analysis with the theoretical frameworks discussed in the literature on DUI recidivism, delivering insightful findings about the effects of DUI penalties on reducing subsequent offenses. By confirming that higher penalties at specific BAC thresholds are associated with decreased recidivism, the research offers strong support for the deterrent effect of stringent legal sanctions, which aligns with the research objectives and reinforces theoretical expectations. This finding is particularly significant as it substantiates the policy argument for harsher penalties to mitigate repeat DUI incidents, a key concern in traffic safety legislation.

However, the analysis reveals that while the initial results indicate a definite impact of DUI penalties on reducing recidivism, the effect size is relatively modest. The R-squared values from both the original and replicated models are very low (0.004 and 0.005, respectively), suggesting that DUI penalties, although statistically significant, explain only a small fraction of the variance in recidivism. This aspect of the findings highlights a crucial point for policymakers and researchers: while increased penalties are effective to a degree, they are not the sole solution to preventing DUI recidivism. This prompts a discussion on the need for a multi-faceted approach that might include educational programs, rehabilitation initiatives, and community-based interventions to complement legal penalties.

The replicated results, which show a more conservative estimate of the DUI penalties' effect, underscore the importance of replication in social science research. By providing a more cautious estimate, the replication adds a layer of robustness to the study's conclusions and suggests that while the penalties' deterrent effect is real, its magnitude might vary depending on sample characteristics and methodological specifics. This variance invites further investigation into the conditions under which DUI penalties are most effective, potentially leading to more tailored and thus more effective policy interventions.

Building on the methods emphasized in the literature review, this study's incorporation of machine learning-enhanced cross-validation techniques in the RDD framework enhances the rigor and credibility of the findings. The literature review underscores the necessity of employing robust cross-validation methods to prevent overfitting and maintain model integrity, especially crucial in RDD applications where the treatment effect is localized around a threshold. By adhering to these methodological enhancements, the study not only aligns with the best practices

highlighted in previous research but also advances the discourse by demonstrating the practical utility of sophisticated statistical techniques in policy evaluation studies.

## **VI. Conclusion**

In conclusion, this research has critically assessed the impact of DUI penalties on recidivism through a refined application of Regression Discontinuity Design (RDD), augmented by sophisticated cross-validation techniques. Our findings, while confirming the deterrent effect of harsher penalties at specific BAC thresholds, reveal that these measures, though statistically significant, have a relatively modest impact on reducing repeat offenses. This underscores a critical insight for policymakers: while steeper penalties can contribute to lower recidivism rates, their influence is limited and should not be viewed as a standalone solution to the problem of DUI offenses.

The modest effect sizes observed, indicated by low R-squared values in both the original and replicated studies, suggest that other factors also play substantial roles in recidivism, which DUI penalties alone may not address. This finding aligns with the theoretical underpinnings discussed in our literature review, emphasizing the need for a comprehensive strategy that includes, but is not limited to, legal sanctions. Future policies might therefore benefit from integrating educational initiatives, rehabilitation programs, and community engagement efforts alongside stricter legal penalties to form a more holistic approach to preventing DUI recidivism.

Additionally, the use of machine learning techniques to optimize RDD analysis, as detailed in our methodology, not only improves the precision of our estimates but also enhances the generalizability of the findings across different datasets. This methodological enhancement contributes to a more robust understanding of the policy measures' effectiveness, supporting the broader applicability of our conclusions in real-world settings.

Looking forward, it is imperative that this research be expanded to explore the effects of penalties on various types of crimes beyond DUI, to better understand the broader implications of punitive measures in criminal behavior modification. Such studies would further enrich our

comprehension of the dynamics at play and aid in the crafting of more effective, evidence-based policy interventions.

## **VII. Citations**

Hansen, Benjamin. "Punishment and Deterrence: Evidence from Drunk Driving." *American Economic Review*, vol. 105, no. 4, pp. 1581-1617. <https://doi.org/10.1257/aer.20130189>

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Kaliappan, Jayakumar et al. "Impact of Cross-Validation on Machine Learning Models for Early Detection of Intrauterine Fetal Demise." *Diagnostics*, vol. 13, 2023, p. 1692. doi:10.3390/diagnostics13101692