Racial Bias in Policing: Evidence from Speeding Tickets

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Princeton University

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Significant disparity across racial groups in criminal justice outcomes

Big question is the extent to which these disparities are due to racial bias

The main challenge is to differentiate between bias and unobserved differences in underlying criminality.
Introduction

- Focus on narrow law enforcement activity – traffic enforcement.
- Test for discrimination in ticket-writing practices of highway patrol officers.
- Look at leniency of officers to different racial groups.
Should we care about speeding tickets?

- About 21% of all drivers receive a speeding ticket each year.
  - Over 40 million motorists.
- About $6.2b total paid each year.
  - Average cost per ticket about $150.
- Probably the most common context for citizen–police interaction.
  - 40m tickets vs. 12m arrests in 2012.
- Officer discretion – who to stop, what speed to charge.
Speed Discounting

- *Speed Discounting* – the practice of officers “partially forgiving” driver’s speeding by charging the driver with a lower speed than observed.

- Motivated by the speeding ticket fine structure.

- Example – officer observes your speed (via radar) as 82 MPH and pulls you over. Knowing that the fine for speeding over 80 is $100 and the fine for speeding at 80 or below is $50, officer cuts you a break and writes that your speed was 80 MPH instead of 82.

- Interested in whether officers are systematically more lenient towards white drivers than black drivers.
• Most measures of racial bias cannot be disaggregated by officer.
  • Many measures use differences in behavior by officer race (e.g. Antonovics & Knight 2007).
  • *Hit rate* analysis requires lots of data (Knowles, Persico, and Todd 2001).
• Intuitive reduced-form measure of discrimination.
  • New method for dealing with issue of unobserved guilt.
• Not as worried about statistical v. taste-based discrimination.
• Setting allows computation of dollar value of discrimination.
North Carolina Highway Traffic Study


Includes officer ID, race, age, and gender of driver, speed limit, charged speed, vehicle characteristics.

Focus on citations involving
- Non-accident related stop
- Black or white driver
- Highways (speed limits of 55–65).
### Summary Stats

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>W</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pct Black</td>
<td>1.0</td>
<td>0.0</td>
<td>0.260</td>
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<tr>
<td></td>
<td>(0.0)</td>
<td>(0.0)</td>
<td>(0.438)</td>
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<tr>
<td>NC License</td>
<td>0.767</td>
<td>0.731</td>
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<tr>
<td></td>
<td>(0.423)</td>
<td>(0.444)</td>
<td>(0.439)</td>
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<td>55 MPH Zone</td>
<td>0.753</td>
<td>0.781</td>
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<td>(0.431)</td>
<td>(0.413)</td>
<td>(0.418)</td>
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<td>60 MPH Zone</td>
<td>0.0455</td>
<td>0.0473</td>
<td>0.0468</td>
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<td>(0.208)</td>
<td>(0.212)</td>
<td>(0.211)</td>
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<td>65 MPH Zone</td>
<td>0.201</td>
<td>0.171</td>
<td>0.179</td>
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<tr>
<td></td>
<td>(0.401)</td>
<td>(0.377)</td>
<td>(0.383)</td>
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<tr>
<td>Car</td>
<td>0.778</td>
<td>0.634</td>
<td>0.672</td>
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<tr>
<td></td>
<td>(0.416)</td>
<td>(0.482)</td>
<td>(0.470)</td>
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<tr>
<td>Light Truck</td>
<td>0.0869</td>
<td>0.119</td>
<td>0.110</td>
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<tr>
<td></td>
<td>(0.282)</td>
<td>(0.323)</td>
<td>(0.313)</td>
</tr>
<tr>
<td>Pickup</td>
<td>0.0469</td>
<td>0.159</td>
<td>0.130</td>
</tr>
<tr>
<td></td>
<td>(0.211)</td>
<td>(0.366)</td>
<td>(0.336)</td>
</tr>
<tr>
<td>Observations</td>
<td>129756</td>
<td></td>
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</tr>
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</table>
Speed less than or equal to 15 MPH over the speed limit:
- 0-5 MPH over: $10
- 6-10 MPH over: $15
- 11-15 MPH over: $30
- Court appearance waived if fine paid.

Speed greater than or equal to 16 MPH over the speed limit:
- Mandatory court appearance ($188 mandatory court fee).
- Discretionary fine.
- Possibility of license suspension, jail time.
Identification Problem

- Interested in quantity

\[ p(\text{discount}|w, s, Z) - p(\text{discount}|b, s, Z) \]

the racial differences in probability of receiving a speed discount, conditional on guilt (speed) s and observables Z.

- If we could observe true speed, could run regression

\[ \text{discount}_j = \alpha + \beta \cdot \text{black}_j + \gamma s_j + \theta Z_j + \epsilon_j \]

- But we can’t...
Speed Discounting by Race
We argue this is mostly due to officer discretion.

Motorists have imperfect control of speeds.

Probability of stop generally an increasing function of speed and speed relative to surrounding cars.

  Inconsistent with density function above.

Considerable variation across officers in degree of bunching.

Anecdotal evidence.
Variation Across Officers

Officer 623

Officer 1144

Officer 347

Officer 1165
Officer $i$ stops motorist $j$ whose *true speed* is $x^*_j > 0$ (unobserved).

Sets *charged speed* $x_j$ (observed).

Based on fine schedule, we assume

- When $x_j \leq 15$, officer sets $x_j = x^*_j$.
- When $x_j \geq 16$, officer sets $x_j \in \{15, x^*_j\}$

If discounting occurs, generates *bunching* in the empirical distribution of $x$. 
Define bunching $b$ at speed $k$ as

$$b_k = f_x(k) - f_{x^*}(k)$$

Bunching at $x = 15$ equals

$$b = p(\text{discount} | x^* > 15)$$

Racial disparities in bunching signals racial differences in preferential treatment.

Want to compute test statistic $d = b_w - b_b$. 
Goal is to estimate $p(x^* = 15)$.

Assumed decision rule tells us

$$f_x = f_x^* \text{ when } x^* < 15$$

Sensible approach is to use observations where $x < 15$ to infer the distribution of $x^*$.

Suppose $x^* \sim \text{Poisson}(\lambda)$.

Then the distribution of $x$ conditional on $x < 15$ is

$$f(x|x < 15) = \frac{1}{G(15; \lambda)} \cdot \frac{\lambda^x \exp(-\lambda)}{x!}$$

where $G$ is CDF of a $\text{Poisson}(\lambda)$.

Can estimate $\hat{\lambda}$ via MLE using only observations where $x < 15$. 
Then estimate bunching via

\[ \hat{b} = p(x = 15) - \frac{\hat{\lambda}^{15} \exp(-\hat{\lambda})}{15!} \]

Variance of \( \hat{b} \) from delta method:

\[ \text{Var}(\hat{b}) = \text{Var}(\hat{\lambda}) \left( \frac{(15 - \hat{\lambda})\hat{\lambda}^{14} \exp(-\hat{\lambda})}{15!} \right)^2 \]
Illustration of Poisson Approach

Goncalves & Mello (Princeton)
## Results

<table>
<thead>
<tr>
<th></th>
<th>(1) Full Sample</th>
<th>(2) Night Stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_w$</td>
<td>0.3397***</td>
<td>0.3383***</td>
</tr>
<tr>
<td></td>
<td>(0.0013)</td>
<td>(0.0016)</td>
</tr>
<tr>
<td>$b_b$</td>
<td>0.302***</td>
<td>0.3028***</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.0031)</td>
</tr>
<tr>
<td>$d$</td>
<td>0.0379***</td>
<td>0.0356***</td>
</tr>
<tr>
<td></td>
<td>(0.0015)</td>
<td>(0.0035)</td>
</tr>
<tr>
<td>Officers</td>
<td>1,155</td>
<td>1,064</td>
</tr>
<tr>
<td>Stops</td>
<td>129,756</td>
<td>21,941</td>
</tr>
</tbody>
</table>
$\bar{d} = 0.026 \pm 0.1197$, $N = 534$.

- 31% of officers with $d > 0$.
- 16.6% of officers have $d < 0$. 

![Histogram of Standardized $d_i$](image)
Correlation across periods

- Period 1
- Period 2

\[
\beta = 0.223 \pm 0.066
\]
To perform counterfactual of distribution without racial bias, we need a model of officer’s ticketing behavior.

Officer $i$ stops motorist $j$ whose *true speed* is $x^* > 0$ (unobserved).

Sets *charged speed* $x$ (observed).

Based on fine schedule, we assume
- When $x \leq 15$, officer sets $x = x^*$.
- When $x \geq 16$, officer sets $x \in \{15, x^*\}$

How does officer decide whether to discount when $x^* > 15$?
Benefit to discounting is the officer’s taste for the motorist:

\[ t_{jr} = t_r + \epsilon_j \]

where \( \epsilon \sim F_r, \ E[\epsilon] = 0, \ Var[\epsilon] = \sigma_r^2. \)

Cost to discounting is \( c(x^*) \), where \( c' > 0. \)

Officer discounts when

\[ t_j \geq c(x^*) \]

We say the officer discriminates when \( t_w \neq t_b. \)
Model III

- Model generates “bunchy” distribution of $x$ at $x = 15$.
- If $x^* \sim G$, $p(x = 15)$ is

$$g(15) + p(\text{discount}|x^* > 15)$$

$$= g(15) + \sum_{k=16}^{\infty} g(k)p(\text{discount}|x^* = k)$$

$$= g(15) + \sum_{k=16}^{\infty} F(t - c(k))$$
Model implies likelihood function for distribution of $x$ for race $r$:

$$l(x) = g_r(x)1_{[x<15]} \times g_r(x) \left[ 1 - \Phi \left( \frac{t_r - c(x)}{\sigma_r} \right) \right] 1_{[x>15]}$$

$$\times \left[ g_r(x) + \sum_k g_r(k) \Phi \left( \frac{t_r - c(k)}{\sigma_r} \right) \right] 1_{[x=15]}$$
Parameterize the model as

\[ x_r^* \sim \text{Poisson}(\lambda_r) \]
\[ \epsilon_r \sim N(0, \sigma_r^2) \]
\[ c(x^*) = a + bx^* \]

Parameters \( a \) and \( b \) aren’t identified in the likelihood function. So set \( a = 0, b = 1 \). The \( t \)’s are rescaled from cost units to MPH units.

Estimate \( \lambda_w, \lambda_b, \sigma_w, \sigma_b, t_w, t_b \) by MLE.

Jointly estimate for blacks and whites.
<table>
<thead>
<tr>
<th></th>
<th>(1) White</th>
<th>(2) Black</th>
<th>(3) Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>λ</td>
<td>18.584</td>
<td>19.143</td>
<td>-.559***</td>
</tr>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.0348)</td>
<td>(0.0401)</td>
</tr>
<tr>
<td>t</td>
<td>20.99</td>
<td>18.375</td>
<td>2.615 ***</td>
</tr>
<tr>
<td></td>
<td>(0.087)</td>
<td>(0.172)</td>
<td>(0.192)</td>
</tr>
<tr>
<td>σ</td>
<td>14.17</td>
<td>15.517</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td>(1.05)</td>
<td></td>
</tr>
</tbody>
</table>
Results

Estimated Probability of Discount

MPH Over

White

Black

Goncalves & Mello (Princeton)
Citation Discrimination
February 16, 2016
Simulation Results

- Simulated 1 mil stops using the estimated distribution of $x^*$ for black drivers.
- Using random draws from the black and white taste distributions, estimate that if officers had the same taste distributions for black and white drivers, share discounted would increase from 0.443 to 0.51.
- Implies a lower bound on the total dollar cost of discrimination in our data is

$$188 \times 1765 \text{ stops}$$

$$= \$332,008$$
Additional cost of exceeding 15 MPH over for blacks due to difference in tastes is

\[ E[\text{cost}|x^* > 15, t = t_b] - E[\text{cost}|x^* > 15, t = t_w] \]

\[ \approx 188 \cdot [p(\text{discount}|x^* > 15, t_w) - p(\text{discount}|x^* > 15, t_b)] \]

\[ = 188 \cdot [0.509 - 0.443] \]

\[ = 12.40 \]

Holding fixed officer likelihood of pulling over black drivers.

Also holding fixed “true” distribution of black speeds.
Florida Data

- **Traffic Tickets**
  - Includes Driver Information (race, gender, age, height, home address, DL number)
  - Officer Name, Badge Number, Troop

- **Florida Department of Law Enforcement Misconduct Database**
  - Includes all cases of misconduct serious enough to be sent to the state level.
  - Includes officer information (race, gender, CJ work experience, education level)
  - Data is kind of messy, we’re still working on matching with traffic tickets.
Florida Data

- Long time window allows us to control for driving history, break down data into more disaggregated measures.
- Check relationship between estimated discrimination and other types of misconduct at the officer-level.
- Accounting for other observables in estimation (e.g. location).
Florida Data

- Restrict attention to tickets where speeding is the main violation.
- White, Black, and Hispanic Drivers.
- Officer is identified.
- 1.2 million observations.
### Summ Stats by Race

<table>
<thead>
<tr>
<th></th>
<th>(1) White</th>
<th>(2) Black</th>
<th>(3) Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. Speed Over (mph)</td>
<td>15.93</td>
<td>16.73</td>
<td>17.90</td>
</tr>
<tr>
<td>Number Obs</td>
<td>883,624</td>
<td>252,390</td>
<td>110,138</td>
</tr>
<tr>
<td>Fraction Obs</td>
<td>.7091</td>
<td>.2025</td>
<td>.0884</td>
</tr>
</tbody>
</table>
Varies by County

Most: 6-9 mph over: $129.00; 10-14 over: $204.00; 15-19 over: $254.00

Drivers also get points on record for speeding. 3 points for 0-15mph over, 4 points for 16+ mph over. With 6 points in a year, license is suspended.
Florida Bunching

Pooled

White

Black

Hispanic

Density

speeddiff

0
10
20
30
40
50

Density

speeddiff

0
10
20
30
40
50

Density

speeddiff

0
10
20
30
40
50
Same as before, we need to estimate the "true" density using some part of the distribution.

We can no longer using the density below the bunch point because almost nobody is charged those speeds.

We instead use the speeds above 15 mph not at bunch points.

Show estimates of bunching at 9 mph over,
### Results

<table>
<thead>
<tr>
<th></th>
<th>(1) Full Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_w$</td>
<td>0.32306***</td>
</tr>
<tr>
<td></td>
<td>(0.00000)</td>
</tr>
<tr>
<td>$b_b$</td>
<td>0.31196***</td>
</tr>
<tr>
<td></td>
<td>(0.00001)</td>
</tr>
<tr>
<td>$b_h$</td>
<td>0.21692***</td>
</tr>
<tr>
<td></td>
<td>(0.00002)</td>
</tr>
<tr>
<td>$b_w - b_b$</td>
<td>0.0111***</td>
</tr>
<tr>
<td></td>
<td>(0.00001)</td>
</tr>
<tr>
<td>$b_w - b_h$</td>
<td>0.10614***</td>
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<tr>
<td></td>
<td>(0.00002)</td>
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</table>
Does Racial Bias Explain the B-W Speed Gap?

R-Square: 0.3971; $\hat{\beta}$: 8.0462; $SE_\beta$: 1.756
Does Racial Bias Explain the H-W Speed Gap?

R-Square: 0.0478; $\hat{\beta}$: 1.4419; $SE_\beta$: 1.0843
Racial Bias and Obama Votes

R-Square: 0.0930; $\hat{\beta}$: -0.9841505; $SE_{\beta}$: 0.3764
Racial Bias and Obama Votes

R-Square: 0.0816; $\hat{\beta}$: -0.1538704; $SE_{\beta}$: 0.0613
### Bunching by Officer-Driver Race

<table>
<thead>
<tr>
<th></th>
<th>(1) White Officers</th>
<th>(2) Black</th>
<th>(3) Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>White Officers</td>
<td>.31</td>
<td>.336</td>
<td>.178</td>
</tr>
<tr>
<td>White Drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>.296</td>
<td>.33</td>
<td>.155</td>
</tr>
<tr>
<td>Hispanic</td>
<td>.199</td>
<td>.276</td>
<td>.233</td>
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### Bunching by Gender

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<thead>
<tr>
<th></th>
<th>(1) Male Officers</th>
<th>(2) Female Officers</th>
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<tbody>
<tr>
<td>$b_{all}$</td>
<td>0.283***</td>
<td>.335***</td>
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<tr>
<td></td>
<td>(0.00007)</td>
<td>(0.00002)</td>
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<tr>
<td>$b_w - b_b$</td>
<td>0.022***</td>
<td>-0.015***</td>
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<tr>
<td></td>
<td>(0.00007)</td>
<td>(0.0029)</td>
</tr>
<tr>
<td>$b_w - b_h$</td>
<td>0.083***</td>
<td>0.1158***</td>
</tr>
<tr>
<td></td>
<td>(0.00009)</td>
<td>(0.00026)</td>
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### Bunching by Education

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<tr>
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<th>(1) Assc Deg</th>
<th>(2) Bach Deg</th>
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</thead>
<tbody>
<tr>
<td>$b_{all}$</td>
<td>0.259***</td>
<td>0.296***</td>
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<tr>
<td></td>
<td>(0.000002)</td>
<td>(0.000001)</td>
</tr>
<tr>
<td>$b_w - b_b$</td>
<td>0.024***</td>
<td>0.013***</td>
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<tr>
<td></td>
<td>(0.000022)</td>
<td>(0.000015)</td>
</tr>
<tr>
<td>$b_w - b_h$</td>
<td>0.101***</td>
<td>0.084***</td>
</tr>
<tr>
<td></td>
<td>(0.000026)</td>
<td>(0.000025)</td>
</tr>
</tbody>
</table>
Next Steps

- Adapt model of officer behavior to Florida data.
- Control for driver history.
- See if racial bias responds to "racial" events.
Thank you!