# An Alternative Test of Racial Prejudice in Motor Vehicle Searches: Theory and Evidence

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# 1 Introduction

- Racial Disparities: Minority motorists in the United States are much more likely than white motorists to be stopped and searched by highway troopers.

- Racial Profiling refers to the police practice of using a motorist's race as one of the criteria in their motor vehicle search decisions.

- Racial profiling originated with the attempt to interdict the flow of drugs from Miami up Interstate 95 to the cities of the Northeast.

- Racial disparities in aggregate stops and searches do *not* imply "racial profiling": If, for example, black drivers are more likely than white drivers to carry contraband, then the aggregate rate of stops and searches would be higher for black drivers even when race was hypothetically invisible to troopers.

- When there is racial profiling, it can arise for two separate reasons:

  – <u>Racism</u> (racial prejudice);

  – <u>Statistical discrimination</u>: police attempt to maximize successful searches and race helps predict whether a driver carries contraband.

- <u>Question of the paper:</u> How do we empirically test if racial profiling is due to racism or statistical discrimination?

## 2 Previous Approaches

- Probit Regressions:
  - Dependent variable: search or not;
  - Independent variables: whatever characteristics avaiable about the driver and vehicle.
  - Problem: Omitted variables.

- Benchmarking: comparing the racial disparities between the search rate for low-discretionary searches and the search rate for high-discretionary searches;

- <u>Outcome Test:</u> Becker (1957)
  - Idea: if troopers are prejudiced against blacks, they would search blacks that are less suspicious. This will imply that the *marginal* search success rate should be lower for blacks than for whites.
  - Problem: Marginal v.s. average

## Outcome Test: Knowles, Persico and Todd (2001, JPE)

- Present a model that rationalizes using average search success rate (or hit rate) as the basis for test.

- $v(c, r)$ : the payoff of carrying contraband if not searched;

- $-j(c, r)$ : the payoff of carrying contraband if searched;

- The distribution of $c$ among race-$r$ motorists is $F_r(c)$.

- $t_r$ : officers' cost of searching race-$r$ motorist.

- "Matching-Pennies" Game between Officers and Motorists of Characteristics $(c, r)$:

| Motorist╲Officer | Search | Not Search |
|---|---|---|
| Carry | $-j(c,r), 1-t_r$ | $v(c,r), 0$ |
| Not Carry | $0, -t_r$ | $0, 0$ |

- Officers with search type-$(c, r)$ motorists with probability

$$\gamma^*(c,r) = \frac{v(c,r)}{v(c,r) + j(c,r)}$$

so that motorists of type $(c, r)$ is exactly indifferent between carrying or not carrying.

- Motorists of type $(c, r)$ will carry contraband with probability

$$P^* (c, r) = t_r$$

so that officers will be exactly indifferent between searching or not searching.

- Thus if officers are not racially prejudice, i.e., $t_A = t_W$, then all drivers of any characteristics $(c, r)$ will carry contraband with equal probability. That is, there is no difference between marginal and average motorist searched.

- Two main objections:

1. Unrealistic prediction that all motorists for a given race, regardless of their other characteristics that may be observed by the police, will carry contraband with equal probability. This implies that a motorist's characteristics other than race should provide no information when a trooper decides whether to search.

2. KPT (and this field of research in general) assume that all troopers' behavior is *monolithic*.

- The consequence of an invalid monolithic trooper behavior assumption is serious. Imagine a world in which minority troopers are racially prejudiced against white motorists, while white troopers are prejudiced against minority motorists. It is possible that when examining the aggregate search outcomes of white and minority troopers, we would reach a conclusion that the police as a whole are not racially prejudiced. But this seriously underestimates the harassment experienced by both white and minority motorists.

# 3 The Model

- Let $r_m$ and $r_p \in \{M, W\}$ denote the race of the motorists and the troopers respectively, where $M$ stands for minorities and $W$ for whites.

- Suppose that among motorists of race $r_m \in \{M, W\}$, a fraction $\pi^{r_m} \in (0, 1)$ of them carry contraband.

- The information that is available to an officer when he or she makes the search decision consists of the motorist's race and:
  - the gender, age and residential address of the driver;
  - the interior of the vehicle that is in the trooper's view;
  - the smell from the driver or the vehicle;
  - whether the driver is intoxicated;
  - the demeanor of the driver in answering the trooper's questions;
  - the make of the car, whether the car has an out-of-state plate, whether the car is rented or owned, location and time of the stop;
  - the seriousness of the reason for the stop, etc.

- We assume that the police officer will use a *single-dimensional index* $\theta \in [0, 1]$ that summarizes all of the information that these characteristics indicate about the likelihood that a driver may be carrying contraband.

- We assume that, if a driver of race $r_m \in \{M, W\}$ actually carries contraband, then the index $\theta$ is randomly drawn from a continuous probability density distribution $f_g^{r_m}(\cdot)$; if a race $r_m$ driver does not carry contraband, $\theta$ would be randomly drawn from $f_n^{r_m}(\cdot)$.

MLRP: $f_g^{r_m}(\theta) / f_n^{r_m}(\theta)$ is strictly increasing in $\theta$; and $f_g^{r_m}(\theta) / f_n^{r_m}(\theta) \to +\infty$ as $\theta \to 1$.

- Let $t(r_m; r_p)$ be the cost of a police officer with race $r_p$ searching a motorist with race $r_m$, where $r_p, r_m \in \{M, W\}$. We normalize the benefit of each arrest (or successful drug find) to equal one, and scale the search cost to be a fraction of the benefit, so that $t(r_m; r_p) \in (0, 1)$ for all $r_m, r_p$.

- Each police officer can choose to search a vehicle after observing the driver's vector $(r_m, \theta)$, where $r_m$ is the driver's race and $\theta$ is the single-dimensional index that summarizes all other characteristics observed during the stop.

- We assume that a trooper wants to maximize the total number of convictions (or the number of drivers found carrying illicit contraband) minus a cost of searching cars.

- Let $G$ denote the event that the motorist searched is found with illicit drugs in the vehicle.

$$\Pr(G|r_m,\theta) = \frac{\pi^{r_m} f_g^{r_m}(\theta)}{\pi^{r_m} f_g^{r_m}(\theta) + (1-\pi^{r_m}) f_n^{r_m}(\theta)}.$$

- The decision problem faced by a police officer of race $r_p$ when facing a motorist with race $r_m$ and signal $\theta$ is thus as follows:

$$\max\{\Pr(G|r_m,\theta) - t(r_m;r_p);0\}$$

Proposition 1 *A race-$r_p$ police officer will search a race-$r_m$ motorist if and only if*

$$\theta \geq \theta^* (r_m; r_p)$$

*where $\theta^* (r_m; r_p)$ is uniquely determined by*

$$\Pr (G | r_m, \theta^* (r_m; r_p)) = t (r_m; r_p) .$$

*Moreover, the search threshold $\theta^* (r_m; r_p)$ is monotonically increasing in $t (r_m; r_p)$.*

- $\theta^* (r_m; r_p)$ is the *equilibrium search criterion* of race-$r_p$ police officers against race-$r_m$ motorists.

- *Equilibrium search rate* of race-$r_p$ police officers against race-$r_m$ motorists is

$$\gamma(r_m; r_p) = \pi^{r_m}\left[1 - F_g^{r_m}(\theta^*(r_m; r_p))\right] + (1 - \pi^{r_m})\left[1 - F_n^{r_m}(\theta^*(r_m; r_p))\right].$$

- *Equilibrium average search success rate* of race-$r_p$ police officers against race-$r_m$ motorists is

$$S(r_m; r_p) = \frac{\pi^{r_m}\left[1 - F_g^{r_m}(\theta^*(r_m; r_p))\right]}{\pi^{r_m}\left[1 - F_g^{r_m}(\theta^*(r_m; r_p))\right] + (1 - \pi^{r_m})\left[1 - F_n^{r_m}(\theta^*(r_m; r_p))\right]}.$$

Definition 1 *A police officer of race* $r_p$ *is racially prejudiced, or has a taste for discrimination, if* $t(M; r_p) \neq t(W; r_p)$.

Definition 2 *The police officers do not exhibit monolithic behavior if* $t(r_m; M) \neq t(r_m; W)$ *for some* $r_m \in \{M, W\}$.

Definition 3 *Assume* $t(M; r_p) = t(W; r_p)$. *Then race-*$r_p$ *police officers exhibit statistical discrimination if* $\theta^*(M; r_p) \neq \theta^*(W; r_p)$.

Proposition 2 *If the police officers exhibit monolithic behavior, then* $\gamma(r_m; M) = \gamma(r_m; W)$ *and* $S(r_m; M) = S(r_m; W)$ *for all* $r_m \in \{M, W\}$.

Proposition 3 *If neither race-*$M$ *nor race-*$W$ *of police officers exhibit racial prejudice, then neither the ranking of* $\gamma(r_m; M)$ *and* $\gamma(r_m; W)$ *nor the ranking of average search success rates* $S(r_m; M)$ *and* $S(r_m; W)$ *depends on* $r_m \in \{M, W\}$. *Moreover, for any* $r_m$*, the ranking of* $\gamma(r_m; M)$ *and* $\gamma(r_m; W)$ *should be the exact opposite of the ranking of* $S(r_m; M)$ *and* $S(r_m; W)$.

- The contrapositive of Proposition 3 is simply that, if the ranking of $\gamma(r_m; M)$ and $\gamma(r_m; W)$, or the ranking of $S(r_m; M)$ and $S(r_m; W)$, depend on $r_m$, then *at least one racial group* of the troopers exhibit racial prejudice. Without further assumptions, it is not possible to determine which group of troopers are racially prejudiced.

## 3.1 Empirical Tests

### 3.1.1 Test for Monolithic Trooper Behavior

- Under the null hypothesis of monolithic trooper behavior, we must have, for all $r_m \in \{M, W\}$,

$$\gamma(r_m; M) = \gamma(r_m; W), \tag{1}$$

$$S(r_m; M) = S(r_m; W). \tag{2}$$

  Any evidence in violation of any of these equalities would reject the null hypothesis.

- Our model is refutable: If the rank order between the search rates between racial groups of troopers for a given race of motorists is not exactly the opposite of the rank order between the average search success rates, then we know that at least some of the conditions of our model are not satisfied.

### 3.1.2 Test for Racial Prejudice

- Under the null hypothesis that none of the racial groups of troopers have racial prejudice, it must be true that both the ranking of search rates for a given race of motorists $r_m$ across the races of troopers $\gamma(r_m; M)$ and $\gamma(r_m; W)$, and the ranking of average search success rates $S(r_m; M)$ and $S(r_m; W)$, do not depend on $r_m \in \{M, W\}$.

- The null hypothesis will be rejected if the ranking of $\gamma(r_m; M)$ and $\gamma(r_m; W)$, or the ranking of $S(r_m; M)$ and $S(r_m; W)$, depends on the race of the motorists $r_m$.

- This test, however, has an asymptotic power less than one.

## 3.2 Discussion of Two Key Assumptions

Assumption on the Pool of Motorists Faced by Troopers of Different Races.

- In the model, we assume that the fraction of race-$r_m$ motorists carrying contraband $\pi^{r_m} \in (0, 1)$ does not depend on the race of the troopers searching them. That is, we assumed that the pools of motorists faced by troopers of different races are the same. This assumption may not be empirically valid if white and minority troopers are systematically assigned to patrol in different locations or time of day.

- We now propose an empirical method that can resolve this problem even when the raw data does not satisfy this condition. For illustration purposes, suppose that there are two troop stations 1 and 2, each with 100 officers. Suppose that in troop station 1, 80 officers are white and 20 are minorities; in station 2, 60 officers are white and 40 are minorities.

- Keep all the minority officers (20 of them) in station 1, but randomly select 47 out of the 80 white officers. Similarly, we keep all the white officers (60 of them) in station 2, but randomly select 26 out of the 40 minority officers.

- Thus we create an artificial sample of 107 white officers and 46 minority officers. Among the 153 officers in the artificial sample, (roughly) 70 percent of them are whites and 30 percent are minorities, and they are equally likely to be assigned to stations 1 and 2.

- To alleviate the sampling error, we use independent resampling to create a list of such artificial data sets.

Assumption on the Signal Distributions.

- In the model we allow the signal distributions $f_g^{r_m}$ and $f_n^{r_m}$ to be specific to the racial group of the drivers. This flexibility is important if we intend to use our model as a basis for empirical test.

- Despite this flexibility, our formulation does assume that the signals of race $r_m$ motorists are drawn from the same distributions independent of police officers' race.

# 4 Test of Monolithic Behavior

- Pearson's $\chi^2$ test statistic under the null hypothesis all troopers with race in $\mathcal{R}$ search race-$r_m$ motorists with equal probability is given by

$$\sum_{r_p \in \mathcal{R}} \frac{\left(\widehat{\gamma(r_m; r_p)} - \widehat{\gamma(r_m)}\right)^2}{\widehat{\gamma(r_m; r_p)}} \sim \chi^2 (R-1).$$

- Pearson's $\chi^2$ test statistics under the null hypothesis that all troopers with race in $\mathcal{R}$ have the same average search success rate against race-$r_m$ motorists is given by

$$\sum_{r_p \in \mathcal{R}} \frac{\left(\widehat{S(r_m; r_p)} - \widehat{S(r_m)}\right)^2}{\widehat{S(r_m; r_p)}} \sim \chi^2 (R-1).$$

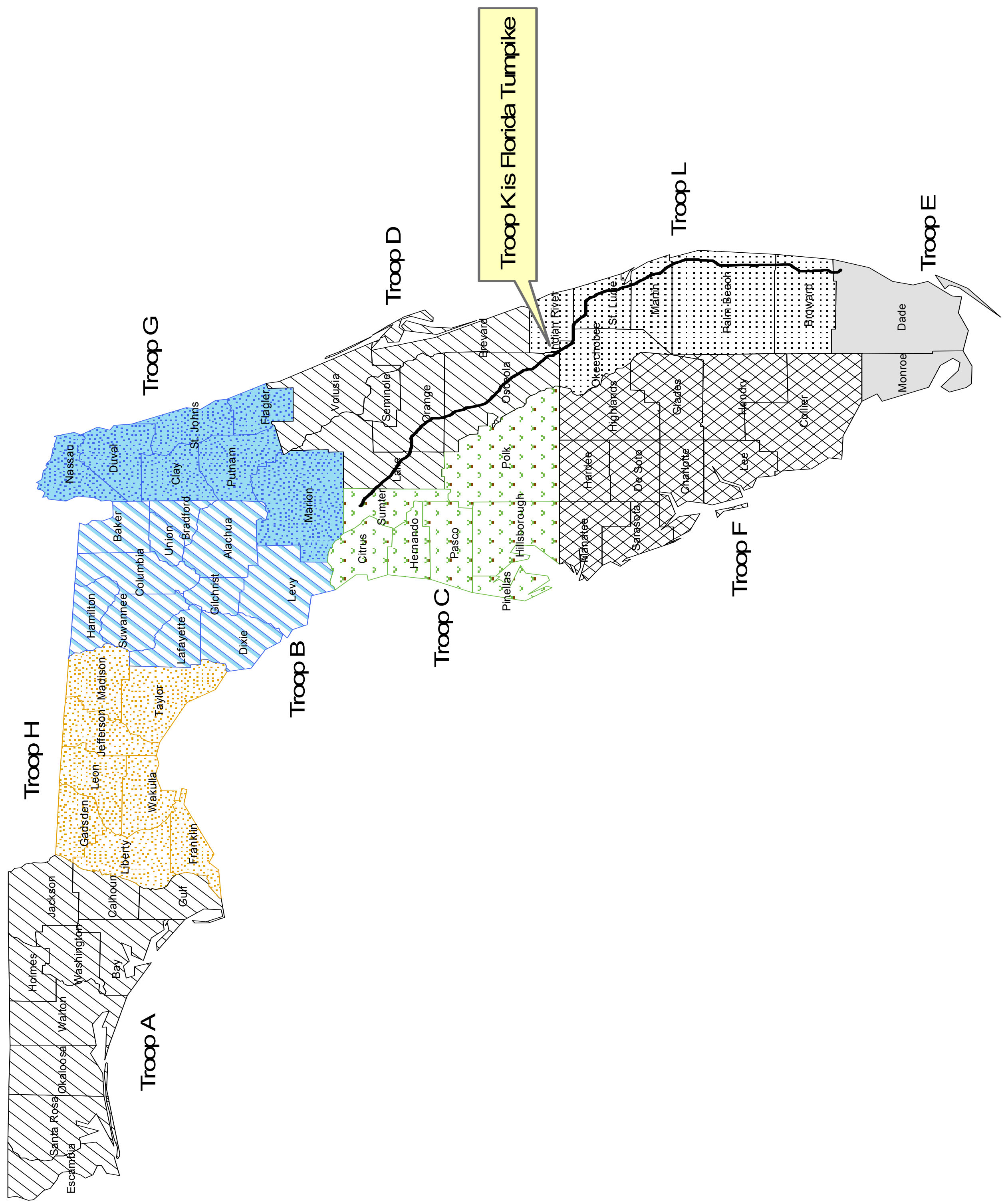


Figure 1: Troop Station Coverage Map

| Motorists' Characteristics | Stops: All Stops | Stops: By Motorist Sex: Female | Stops: By Motorist Sex: Male | Searches: All Searches | Searches: By Motorist Sex: Female | Searches: By Motorist Sex: Male |
|---|---|---|---|---|---|---|
| Black | .162 (.368) | .327 (.470) | .673 (.470) | .221 (.415) | .146 (.354) | .851 (.354) |
| Hispanic | .173 (.378) | .225 (.417) | .775 (.471) | .234 (.423) | .098 (.296) | .902 (.296) |
| White | .665 (.472) | .319 (.466) | .681 (.466) | .546 (.498) | .178 (.382) | .822 (.382) |
| Female | .304 (.460) | 1.00 (.00) | 0.00 (.00) | .152 (.359) | 1.00 (.00) | 0.00 (.00) |
| Male | .696 (.460) | 0.00 (.00) | 1.00 (.00) | .848 (.359) | 0.00 (.00) | 1.00 (.00) |
| Age: | | | | | | |
| 16-30 | .481 (.500) | .325 (.468) | .675 (.468) | .584 (.493) | .149 (.356) | .851 (.356) |
| 31-45 | .336 (.472) | .295 (.456) | .705 (.456) | .317 (.465) | .162 (.368) | .838 (.368) |
| 46+ | .183 (.386) | .269 (.444) | .731 (.444) | .099 (.299) | .136 (.343) | .864 (.343) |
| License Plate: | | | | | | |
| In-state | .899 (.302) | .310 (.462) | .690 (.462) | .857 (.350) | .155 (.362) | .845 (.362) |
| Out-of-state | .101 (.302) | .252 (.434) | .748 (.434) | .143 (.350) | .132 (.338) | .868 (.338) |
| Time: | | | | | | |
| Day (6am-6pm) | .697 (.459) | .316 (.465) | .684 (.465) | .475 (.499) | .161 (.367) | .839 (.367) |
| Night | .303 (.459) | .275 (.447) | .725 (.447) | .525 (.499) | .144 (.351) | .856 (.351) |
| Contraband Seized: | | | | | | |
| None | | | | .792 (.406) | .155 (.362) | .845 (.362) |
| Drugs | | | | .151 (.358) | .137 (.344) | .863 (.344) |
| Paraphernalia | | | | .015 (.122) | .156 (.364) | .844 (.364) |
| Currency | | | | .003 (.051) | .174 (.388) | .826 (.388) |
| Vehicles | | | | .010 (.100) | .154 (.363) | .846 (.363) |
| Alcohol/Tobacco | | | | .021 (.142) | .151 (.359) | .849 (.359) |
| Weapons | | | | .006 (.078) | .055 (.229) | .945 (.229) |
| Other | | | | .003 (.049) | .318 (.477) | .682 (.477) |
| Number of Observations: | 906,339 | 275,527 | 630,812 | 8,976 | 1,364 | 7,612 |

Table 1: Means of Variables Related to Motorists.

Note: Standard errors of the means are shown in parentheses.

| Troopers' Characteristics | Troopers: All Troopers | Stops: All Stops | Stops: By Trooper Sex: Female | Stops: By Trooper Sex: Male | Searches: All Searches | Searches: By Trooper Sex: Female | Searches: By Trooper Sex: Male |
|---|---|---|---|---|---|---|---|
| Black | .137 | .160 | .115 | .885 | .046 | .044 | .956 |
| | (.344) | (.366) | (.319) | (.319) | (.208) | (.206) | (.206) |
| Hispanic | .100 | .114 | .070 | .930 | .095 | .025 | .975 |
| | (.300) | (.318) | (.256) | (.256) | (.293) | (.155) | (.155) |
| White | .763 | .726 | .092 | .908 | .859 | .076 | .924 |
| | (.425) | (.446) | (.289) | (.289) | (.348) | (.265) | (.265) |
| Female | .106 | .093 | 1.00 | 0.00 | .069 | 1.00 | 0.00 |
| | (.307) | (.291) | (.00) | (.00) | (.254) | (.00) | (.00) |
| Male | .894 | .907 | 0.00 | 1.00 | .931 | 0.00 | 1.00 |
| | (.307) | (.291) | (.00) | (.00) | (.254) | (.00) | (.00) |
| Ranks: | | | | | | | |
| Captain | .022 | .002 | .239 | .761 | .002 | .474 | .526 |
| | (.148) | (.041) | (.426) | (.426) | (.046) | (.513) | (.513) |
| Lieutenant | .070 | .013 | .023 | .977 | .007 | .000 | 1.000 |
| | (.255) | (.112) | (.151) | (.151) | (.081) | (.000) | (.000) |
| Sergeant | .145 | .062 | .054 | .946 | .053 | .052 | .948 |
| | (.352) | (.241) | (.226) | (.26) | (.224) | (.223) | (.223) |
| Corporal | .147 | .112 | .068 | .932 | .071 | .030 | .970 |
| | (.354) | (.316) | (.252) | (.252) | (.257) | (.170) | (.170) |
| LEO | .602 | .810 | .101 | .899 | .866 | .073 | .927 |
| | (.490) | (.392) | (.301) | (.301) | (.341) | (.261) | (.261) |

Table 2: Means of Variables Related to Troopers.

Note: Standard errors of the means are shown in parentheses.

| Motorist's Race | Motorist's Characteristics | White Troopers | Black Troopers | Hispanic Troopers | $p$-value |
|---|---|---|---|---|---|
| White | Male | .679 | .684 | .701 | <.001 |
| | Night stops | .288 | .272 | .318 | <.001 |
| | Age: 16-30 | .471 | .460 | .445 | <.001 |
| | Age: 31-45 | .325 | .341 | .349 | 0.02 |
| Black | Male | .671 | .667 | .686 | <.001 |
| | Night stops | .332 | .308 | .354 | <.001 |
| | Age: 16-30 | .514 | .514 | .507 | .001 |
| | Age: 31-45 | .340 | .344 | .356 | 0.03 |
| Hispanic | Male | .783 | .774 | .761 | <.001 |
| | Night stops | .322 | .288 | .393 | <.001 |
| | Age: 16-30 | .516 | .497 | .494 | <.001 |
| | Age: 31-45 | .350 | .363 | .355 | 0.01 |

Table 3: Distribution of Characteristics of Stopped Motorists, by Trooper Race in the Raw Data.

| | Troopers' Race | | |
|---|---|---|---|
| | White | Black | Hispanic |
| Troop | | | |
| A | .930 (.256) | .054 (.227) | .016 (.124) |
| B | .889 (.316) | .081 (.274) | .030 (.172) |
| C | .816 (.389) | .116 (.321) | .068 (.253) |
| D | .793 (.406) | .117 (.322) | .090 (.287) |
| E | .412 (.494) | .236 (.426) | .352 (.479) |
| F | .880 (.326) | .056 (.231) | .063 (.245) |
| G | .833 (.374) | .135 (.343) | .032 (.176) |
| H | .886 (.320) | .114 (.320) | 0.00 (.00) |
| K | .698 (.461) | .147 (.355) | .155 (.364) |
| L | .603 (.491) | .298 (.459) | .099 (.300) |
| % Night Stops | .283 (.172) | .284 (.192) | .349 (.179) |

Table 4: Proportion of Troopers with Different Races by Troop and Time Assignment in the Raw Data.

Note: Standard errors of the means are shown in parentheses

# 5 Data

- Data from the Florida State Highway Patrol. It is composed of two parts.

- The first is the *traffic* data set that consists of all the stops and searches conducted on all Florida highways from January 2000 to November 2001. For each of the stops in the data set, it includes (among other things) the date, exact time, county, driver's race, gender, ethnicity, age, reason for stop, whether a search was conducted, rationale for search, type of contraband seized, and the ID number of the trooper who conducted the stop and/or search.

- The second part is the *personnel* data that contains information on each of the troopers that conducted the stops and searches in the traffic data set, including their ID number, date of birth, date of hiring, race, gender, rank, and base troop station.

- The merged data set includes 906,339 stops and 8,976 searches conducted by a total of 1,469 troopers.

## 6 Test for Racial Prejudice

- We use simple $Z$-statistics to formally test that

$$\gamma(r_m; W) > \gamma(r_m; H) > \gamma(r_m; B), \quad (3)$$
$$S(r_m; W) < S(r_m; H) < S(r_m; B). \quad (4)$$

- For example, let the null hypothesis be $\gamma(r_m; W) = \gamma(r_m; H)$. We can test it against the one-sided alternative hypothesis $\gamma(r_m; W) > \gamma(r_m; H)$ by using

$$Z = \frac{\gamma\widehat{(r_m; W)} - \gamma\widehat{(r_m; H)}}{\sqrt{\frac{\mathsf{SVar}_W}{n_W} + \frac{\mathsf{SVar}_H}{n_H}}}.$$

| Motorist's Race | Trooper Race: White | Black | Hispanic | $p$-value |
|---|---|---|---|---|
| **Panel A: Search Rate Given Stop (%)** | | | | |
| White | 0.96<br>(6.68E-4) | 0.27<br>(7.73E-4) | 0.76<br>(9.26E-4) | $< 0.001$ |
| Black | 1.74<br>(1.30E-3) | 0.35<br>(1.42E-3) | 1.21<br>(2.28E-3) | $< 0.001$ |
| Hispanic | 1.61<br>(1.46E-3) | 0.28<br>(0.76E-3) | 0.99<br>(3.03E-3) | $< 0.001$ |
| **Panel B: Average Search Success Rate (%)** | | | | |
| White | 24.3<br>(9.43E-3) | 39.4<br>(5.57E-2) | 26.0<br>(2.28E-2) | $< 0.001$ |
| Black | 19.9<br>(1.26E-2) | 26.0<br>(5.32E-2) | 20.8<br>(2.67E-2) | $< 0.001$ |
| Hispanic | 8.5<br>(9.78E-3) | 21.0<br>(4.55E-2) | 14.3<br>(6.63E-2) | $< 0.001$ |

Table 5: Search Rates and Average Search Success Rates by Races of Motorists and Troopers in the Artificial Data Sets.
Note: Standard errors of the means are shown in parentheses.

## 6.1 Other Implications from the Tests

- A ranking over the search costs: for any $r_m$,

$$t(r_m; W) < t(r_m; H) < t(r_m; B).$$

  That is, white troopers seem to have smaller costs of searching motorists of any race, followed by Hispanic troopers. Black troopers have the highest search costs.

- The statistical evidence in our data does not refute our model.

| Motorist's Race | Search Rate (%) | Average Search Success Rate (%) |
|---|---|---|
| White | 0.81 | 25.1 |
| | (.090) | (.434) |
| Black | 1.35 | 20.9 |
| | (.115) | (.407) |
| Hispanic | 1.34 | 11.5 |
| | (.115) | (.319) |

Table 6: Average Search Success Rates by Race of Motorists in the Raw Data.

Note: Standard errors of the means are shown in parentheses.

| Groupings | Search Rate | Average Search Success Rate |
|---|---|---|
| White, Black, Hispanic | $< 0.001$ | $< 0.001$ |
| White, Black | $< 0.001$ | $< 0.001$ |
| White, Hispanic | $< 0.001$ | $< 0.001$ |
| Black, Hispanic | 0.798 | $< 0.001$ |

Table 7: $p$-Values from Pearson's $\chi^2$ Tests on the Hypothesis that Search Rate and Average Search Success Rate are Equal Across Various Groupings.