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**Racial Bias in Motor Vehicle Searches: Additional Theory and Evidence**

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## **Abstract**

Knowles, Persico, and Todd (2001) develop a model of police search and offender behavior. Their model implies that if police are unprejudiced the rate of guilt should not vary across groups. Using data from Interstate 95 in Maryland, they find equal guilt rates for African-Americans and whites and conclude that the data is not consistent with racial prejudice against African-Americans. This paper generalizes the model of Knowles, Persico, and Todd by accounting for the fact that potential offenders are frequently not observed by the police and by including two different levels of offense severity. The paper shows that for African-American males the data is consistent with prejudice against African-American males, no prejudice, and reverse discrimination depending on the form of equilibria that exists in the economy. Additional analyses based on stratification by type of vehicle and time of day were conducted, but did not shed any light on the form of equilibria that best represents the situation in Maryland during the sample period.

We would like to thank John Knowles and the Maryland ACLU for providing the data.

## 1) Introduction

The issue of racial bias in law enforcement has attracted considerable attention in recent years. For example, on I-95 in the state of Maryland during the period January 1995 - January 1999, African-American motorists accounted for only 18 percent of motorists on the road, but represented 63 percent of motorists searched (Knowles, Persico, and Todd, 2001).<sup>1</sup> The fundamental problem with this type of racial comparison is that the observed differences may reflect racial differences on the attributes that police consider when deciding which motorists to cite, search, or arrest. This classic omitted variable problem has been raised in relation to work on discrimination in labor and mortgage markets as well, but is especially problematic in the case of racial profiling. Most law enforcement databases only contain information on the individuals who the police actually chose to cite, search, or arrest, and little if any information is available to describe the attributes of the population that the police observed when making these decisions.

Performance approaches have often been considered as an alternative test for prejudice-based discrimination when direct analysis of racial differences is thought to suffer from omitted variable bias. The logic behind performance analysis is that if decision makers are prejudiced against minorities then the minorities who are selected must have exhibited superior performance in order to compensate the decision maker for selecting minority candidates. For example, Szymanski (2000) finds evidence of prejudice-based discrimination in English soccer leagues by examining the performance of soccer teams after controlling for each team's wage bill. Berkovec, Gabriel, Canner, and Hannan (1998, 1994) examine racial differences in default using a publicly available FHA foreclosure database, and find no evidence of prejudice-based discrimination. Ross (2000, 1997, 1996) and Ross and Yinger (2002, Chapter 8) argue that the default approach does not provide a valid test for discrimination. Specifically, a default analysis suffers from the same omitted variable bias as direct examinations of lender underwriting decisions, but the bias works in the opposite direction.<sup>2</sup> Moreover, unlike a direct regression, the

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<sup>1</sup> Similarly, a study of Tulsa, OK (Ayres, 2000) shows that African-American motorists are much more likely to be issued traffic citations, have their automobiles searched, or be arrested than white motorists. In Tulsa during the period June 1995 - June 2000, African-Americans were 14 percent of the population (and most likely a much smaller fraction of the drivers because of the large number of white suburban commuters and the lower incidence of automobile ownership among African-Americans), but received 23 percent of citations. Furthermore, African-American motorists were 4 times as likely to be arrested (Ayres, 2000).

<sup>2</sup> Another criticism discussed by Ross (2000, 1997, 1996) is that performance approaches cannot capture statistical discrimination, where factors that influence performance are correlated with race and unobserved by both the researcher and the decision maker, and in the case of mortgage default the existence of statistical discrimination may

complete elimination of the omitted variable bias results in a test with no power because it also eliminates the selection bias on which the default approach is based.

A major recent contribution to both the debate over racial bias in law enforcement and the methodological debate over performance approaches as tests for discrimination is Knowles, Persico and Todd (2001) (hereafter referred to as KPT). They develop a model of strategic behavior by police (in their choice of motorists to search) and motorists (in their decision to carry contraband), and show that the equilibrium involves randomization by both police and offenders. Their model implies that in equilibrium the probability of guilt for motorists who are searched should be equal across races, unless the police are prejudiced against one group (in the sense that the police are willing to search that group even when the expected return is lower than that for the other group).<sup>3</sup> KPT use a dataset on police stops along Interstate-95 in Maryland, collected by the Maryland ACLU in connection with a lawsuit against the state. They find equal guilt rates for African-Americans and whites and conclude that the data is not consistent with the hypothesis of racial prejudice against African-Americans.<sup>4</sup>

Their model suggests that the omitted variable bias problem may not be present in performance approaches due to the adjustments made by individuals in equilibrium. The randomizing equilibrium suggested in KPT breaks the link between the expected return to an action and the observed frequency of that action, and in doing so breaks the link between observed frequency and the unobservable individual attributes that are correlated with the expected return. Moreover, the model proposed by KPT might be reasonably applied to other markets. For example, a randomizing equilibrium similar to that proposed by KPT might be relevant to the labor market separation process where workers and employers must make decisions about shirking and monitoring (Shapiro and Stiglitz, 1984) or to the mortgage market where asymmetric information leads to credit rationing and an associated randomization of underwriting decisions (Besanko and Thakor, 1987; and Calem and Stutzer, 1995).

This paper generalizes the KPT model to account for the possibility that potential offenders are frequently not observed by the police (which creates the possibility that some types

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bias the default test away from finding discrimination. See Borooah (2001) for a discussion of statistical discrimination in the context of racial bias in policing.

<sup>3</sup> Intuitively, this equality holds because potential offenders adjust their behavior in response to the possibility of being searched by the police. Those who may appear to have the most to gain from carrying contraband will also be the most likely searched if they do not adjust their behavior.

<sup>4</sup> KPT, as well as Ayres (2000), use microdata drawn from a specific geographic area. See Donohue and Levitt (2001) for an analysis of racial differences in arrests using aggregate data across 134 metropolitan areas.

do not randomize), and by including two different levels of offense severity.<sup>5</sup> Multiple types of equilibria exist in models where potential offenders may not be observed by the police, and the test applied in KPT only provides a valid test for prejudice for the class of equilibria where all potential offenders randomize. Using the model with imperfect observation and two offense levels, this paper develops valid tests for prejudice for each class of equilibria. The paper shows that the Maryland data is consistent with prejudice against African-American males, with no prejudice, and with reverse discrimination, depending on the assumption about which equilibrium is being played. Additional empirical analysis is conducted in an attempt to identify the form or forms of equilibria that are consistent with the data. An analysis using a time of day variable is not consistent with any form of equilibria considered and suggests that other maintained assumptions, such as uniform returns to arrest or uniform search costs, may be violated in the data.

These results suggest that theory is unlikely to solve the omitted variables problem often associated with tests for racial prejudice and discrimination in law enforcement or in any other markets. The remainder of the paper is organized as follows. Section 2 presents the basic model from KPT. Sections 3 and 4 present the model extensions and empirical analyses, respectively. Section 5 briefly summarizes the results and discusses the broader implications of these findings.

## 2) The Basic Model

KPT develop a model that has two types of actors – a continuum of motorists and a continuum of police officers. Each motorist is characterized by  $(c, r)$ , where  $r \in \{A, W\}$  is the motorist's race (either African-American (A) or white (W)), and  $c$  is a continuous variable that represents the motorist's nonracial characteristics. Note that  $c$  is observable to the police, but is unobserved (or only partially observed) by the researcher. Given their characteristics, and the anticipated probability of being searched by the police, motorists choose whether or not to carry drugs. Each motorist receives a default payoff of 0 from not carrying drugs (whether or not she is searched). If a motorist of type  $(c, r)$  chooses to carry drugs, she receives a payoff of  $v(c, r)$  if not searched and  $-j(c, r)$  if searched.

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<sup>5</sup> Persico (2002) extends the KPT model in a number of directions, but does not deal with the particular issues that we focus on.

The police observe each motorist's characteristics  $(c, r)$ , and decide whether or not to search. Crucially, KPT assume that, for any type  $(c, r)$ , the police can choose any search probability  $\gamma \in [0, 1]$ . The police have the following objective function: to maximize expected benefits (where the benefit from a successful search is normalized to 1), net of the cost to the police of searching cars. This cost can depend on the motorist's race, and is denoted by  $t_W, t_A \in (0, 1)$ , for  $r = W, A$ , respectively. KPT define the preferences of the police as being "prejudiced" against A's if  $t_W < t_A$  (i.e. if the police have lower costs of searching A's, for a given benefit).

The game between motorists and the police does not have a pure strategy equilibrium. To see the intuition for this, suppose some type  $(c, r)$  were to decide to always carry drugs; then, the police would always search motorists of this type. But, given that they will always be searched, this type of motorist is better off not carrying drugs (thereby receiving a payoff of 0 rather than  $-j(c, r)$ ). Similarly, if some type  $(c, r)$  were to never carry drugs, the best response of the police would be to never search that type; however, given that one is never searched, a motorist's best response (for  $v(c, r) > 0$ ) is to carry drugs.<sup>6</sup>

Thus, KPT analyze a mixed-strategy equilibrium, where motorists randomize over whether to carry drugs, and the police randomize over whether to search. In this equilibrium, it is possible that a motorist's probability of being searched depends on race. However, if police are unprejudiced (i.e.  $t_W = t_A \equiv t$ ), then it follows that the probability of guilt (denoted  $D$ ) for motorists of each race is the same in equilibrium – i.e.

$$D(W) = D(A) = t$$

If this is the case, then any difference in the search probabilities across the races can be interpreted as "statistical discrimination" (in the sense of being caused by the efforts of the police to apprehend motorists carrying drugs), rather than being attributable to prejudice.

### 3) Extensions to the Basic Model

Our objective in this section is to extend the basic KPT model sketched above in two distinct directions. The first of these relates to what we term "imperfect observation." As highlighted above, KPT assume that, for any type  $(c, r)$ , the police can choose any search probability  $\gamma \in [0, 1]$ . We modify this by allowing for the possibility that not all motorists are

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<sup>6</sup> Of course, it is possible that some types of motorists receive a zero or negative payoff from carrying drugs, even when facing a zero probability of search. However, such types will never carry or be searched in equilibrium, and so will not appear in the data on police searches.

observed by the police. If police do not observe all motorists, equilibria may exist in which some agents do not randomize. In those equilibria, racial differences in the distribution of  $c$  will be correlated with guilt probability, and an empirical test that does not control for  $c$  will not be valid. Secondly, we allow for different levels of offense severity – in particular, while KPT allow each motorist only a binary choice of whether or not to carry drugs, we expand this choice set to permit motorists to choose between carrying no drugs, committing a low-severity offense, and committing a high-severity offense. Potential offenders sort over low and high severity offenses based on  $c$  in equilibrium. For equilibria involving non-randomizing offenders, offense severity can be used to restrict the sample to randomizers providing valid tests for prejudice.

### **3.1) Imperfect Observation**

A crucial assumption of KPT's model is that the police observe *all* motorists, and can choose to search any motorist with probability one. In these circumstances, they argue that: "For our test to fail, we would need to have a fraction of "crazy" criminals who are not deterred even if they know *for sure* that they are going to be caught" (KPT, p. 214, fn. 16). This assumption requires that the police are omniscient (or at least omnipresent), and thus seems to strain credibility. A simple generalization of the KPT model is thus to assume that the police do not necessarily observe every motorist with certainty; rather, there is a probability  $m \in (0, 1)$  that any given motorist is observed.<sup>7</sup> We reinterpret the probability of search  $\gamma \in [0, 1]$  as the probability that the police search a motorist, *conditional* on observing her. Thus, the highest feasible *unconditional* probability of search is  $m$ ; this occurs if the police always search a given type contingent on observing that type (i.e. set  $\gamma = 1$  for that type).

If the motorist is observed (with probability  $m$ ), then she faces a  $\gamma$  probability of search. If the motorist is not observed (with probability  $(1 - m)$ ), she gets the payoff  $v$  if she carries drugs. Thus, KPT's Eq. (1) (p. 209) – the expected payoff to a motorist of type  $(c, r)$  from carrying drugs – now becomes:

$$m(-\gamma(c, r)j(c, r) + (1 - \gamma(c, r))v(c, r)) + (1 - m)v(c, r) \quad (1)$$

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<sup>7</sup> The data includes all searches carried out on a stretch of I-95 in Maryland between 1995 and 1999. There are many reasons why the police may not have observed *every* motorist who traveled within or through the state during this period, such as the limited resources and/or limited attention of the police. In fact, many variables that influence the decision to search may only be apparent after the police have stopped the vehicle. Police only have the resources to stop a very small fraction of all vehicles and even a small fraction of people who commit traffic violations, and thus police can only observe many attributes relevant to search for a small fraction of motorists. In practice,  $m$  may be quite small.

The motorist will be willing to randomize if the expression above equals 0. Rearranging, we obtain the following expression (analogous to that in KPT, p. 211) for the critical value  $\gamma^*(c, r)$  that makes type  $(c, r)$  willing to randomize:

$$\gamma^*(c, r) = \frac{v(c, r)}{m(v(c, r) + j(c, r))} \quad (2)$$

In KPT's model,  $\gamma^*(c, r) < 1$  for any type  $(c, r)$ : every type of motorist is willing to randomize for some feasible search probability  $\gamma^*(c, r)$ . Here, in contrast, since  $(1/m) > 1$ , it is possible that  $\gamma^*(c, r) > 1$  for some types of motorists, so that there are some types who are not willing to randomize for any feasible  $\gamma$ . These types will carry drugs with probability 1, and the police will set  $\gamma = 1$  for these types (i.e. will search them whenever they are observed). It is important to stress that such a motorist is not “crazy” (in the sense used by KPT, p. 214, fn. 16), because she is not facing an *unconditional* probability of search of one. For those types that always carry drugs, the rewards are sufficient to outweigh a probability  $m$  of being searched.

Our seemingly minor change in assumptions has quite drastic consequences for the equilibrium, and for the validity of KPT's test for prejudice. These can be most easily explained in the simple case where  $c$  (like  $r$ ) is binary (say,  $c \in \{0, 1\}$ ); as will be explained below, this does not involve any significant loss of generality. When  $c \in \{0, 1\}$ , KPT's mixed-strategy equilibrium can be characterized as follows:

- 1) the police randomize by setting  $\gamma^*(0, W), \gamma^*(0, A), \gamma^*(1, W), \gamma^*(1, A) \in (0, 1)$
- 2) all motorists randomize by setting the probability of carrying drugs (denoted by  $P^*(G)$ ) to  $P^*(G | 0, W) = P^*(G | 1, W) = t_W$  and  $P^*(G | 0, A) = P^*(G | 1, A) = t_A$

where  $P^*(G | c, r)$  denotes the equilibrium probability of guilt of a motorist, conditional on the motorist's type  $(c, r)$ : i.e. the probability with which motorists of type  $(c, r)$  choose to carry drugs.

Consider a situation where  $\gamma^*(1, A), \gamma^*(1, W) \geq 1$  (i.e. there does not exist an equilibrium where the police randomize over searching motorists of type  $c = 1$ ), while  $\gamma^*(0, W), \gamma^*(0, A) < 1$  (so that the police are willing to randomize over searching motorists of type  $c = 0$ ). Thus, motorists of type  $c = 1$  will always carry drugs; for convenience, we will refer to type  $c = 1$  as “dealers” (and to type  $c = 0$  as “nondealers”) because the former receive a larger net benefit from carrying drugs (this is of course without loss of generality, as the labeling of types is arbitrary).



Note that we focus on “racially symmetric” strategy profiles. Alternative, non-symmetric profiles exist where, for example  $\gamma^*(1, A), \gamma^*(0, A) \geq 1$  and  $\gamma^*(1, W), \gamma^*(0, W) < 1$ . These equilibria, however, are not consistent with the empirical evidence because neither white nor African-American motorists have guilty rates near one.

For the police to be willing to randomize over searching motorists of type  $c = 0$ , it has to be the case that:

$$mP^*(G | 0, W) = t_W$$

and

$$mP^*(G | 0, A) = t_A$$

i.e. the expected payoff of the police is zero (the benefit to police from an arrest is normalized to 1, so the expected payoff is the (unconditional) probability of arrest, minus the cost of search). For motorists of type  $c = 0$  to be willing to randomize, it has to be that case that  $(t_W/m) < 1$  and  $(t_A/m) < 1$ . This is analogous to KPT’s assumption that  $t_W < 1$  and  $t_A < 1$  (p. 209).<sup>8</sup> Given these assumptions, we can characterize a mixed-strategy equilibrium as follows:

- 1) the police randomize over  $c = 0$  types by setting  $\gamma^*(0, W), \gamma^*(0, A) \in (0,1)$
- 2) the police always search  $c = 1$  types whenever they are observed: i.e.  $\gamma^*(1, W) = \gamma^*(1, A) = 1$
- 3) motorists of type  $c = 0$  randomize by setting the probability of carrying drugs to  $P^*(G | 0, W) = t_W/m$  and  $P^*(G | 0, A) = t_A/m$
- 4) motorists of type  $c = 1$  always carry drugs – i.e.  $P^*(G | 1, W) = P^*(G | 1, A) = 1$

Now consider the empirical implications of this equilibrium. Suppose initially that the distribution of types is identical across races – i.e.

$$\Pr[c = 1 | r = A] = \Pr[c = 1 | r = W] \text{ and } \Pr[c = 0 | r = A] = \Pr[c = 0 | r = W]$$

Under these circumstances, if there is no prejudice (i.e.  $t_W = t_A = t$ ), then it follows that:

$$D(W) = D(A) = t$$

So the KPT test for prejudice remains valid. However, note that in our extension the validity of this test depends crucially on the distribution of nonrace characteristics  $c$  across races. For instance, suppose that

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<sup>8</sup> If this is not true, then either one or both of types  $(0, W)$  and  $(0, A)$  will always carry drugs; this case is uninteresting, because it would mean that the data is completely uninformative about police prejudice. Hence, we restrict attention to the case where  $(t_W/m) < 1, (t_A/m) < 1$ .

$$\Pr[c = 1 \mid r = A] > \Pr[c = 1 \mid r = W]$$

(so that a larger fraction of A's (relative to W's) are "dealers"). In the equilibrium specified above,  $P^*(G \mid 1, \cdot) = 1$  for dealers of both races. Thus, police search behavior when a  $c = 1$  type is observed is uninformative about police prejudice. This is because, by assumption,  $t_W, t_A \in (0, 1)$ ; hence,  $\gamma^*(1, W) = \gamma^*(1, A) = 1$  is consistent with any admissible  $t_W$  and  $t_A$ . On the other hand, as  $c = 0$  types of both races are randomizing, the KPT argument applies: if  $t_W = t_A = t$ , then it follows that  $P^*(G \mid 0, W) = P^*(G \mid 0, A) = t$ .

When there are more dealers among A's than among W's, the fraction of  $(1, A)$  types who are found guilty (as a fraction of all A's searched) will be larger than the corresponding fraction among W's. Combining this with the equal values of  $P^*$  for  $c = 0$  types of both races, it follows that if the police are unprejudiced, then the observed probability of guilt has to be *higher* for A's (i.e.  $D(A) > D(W)$ ). In other words, observing equal D's for the two races may well be consistent with police prejudice. Thus, the KPT test for prejudice is not valid when the equilibrium generating the observed outcomes is of the form specified above.

Finally, note that while we have assumed that  $c$  is a discrete variable for expositional ease, the basic argument above is unaffected by assuming a continuous  $c$ . In KPT's model, for each type  $(c, r)$ , there exists some search probability  $\gamma^*(c, r) < 1$  for which that type is willing to randomize. Once we introduce imperfect observation ( $m < 1$ ), the expression for this probability is given by Eq. (2) above. When  $m < 1$ , if there is any  $c$  for which  $\gamma^*(c, r) \geq 1$ , then the KPT test is no longer valid. Such a type would set  $P^*(G) = 1$ , and the police would set  $\gamma^*(c, r) = 1$ ; the latter's search behavior would not be informative about the presence of prejudice. Note, moreover, that for lower values of  $m$ , it becomes more reasonable to suppose that  $\gamma^* \geq 1$  for some type. Thus, unless there are strong grounds for believing that  $m = 1$ , it appears unreasonable to restrict attention to the case where all types of motorists randomize.

### **3.2) Offense Severity**

In this section, we retain the assumption of imperfect observability, and extend the KPT model in another direction, namely to consider offenses of varying severity. In their empirical analysis, KPT consider a number of different definitions of guilt, taking into account variations in the quantity and type of drugs carried by motorists. However, their theoretical model only allows only two (pure strategy) choices for the motorist: to carry or not carry drugs. Here, we introduce the possibility that there are two levels of offenses – a less severe offense (such as

carrying a small quantity of drugs), denoted by L, and a high-severity offense (such as carrying a large quantity of drugs or carrying “hard” drugs), denoted by H. Each motorist thus has three pure strategies: to carry nothing (denoted N), L and H.

Let the payoff from committing L be denoted by  $v_L(c, r)$  if not searched, and  $-j_L(c, r)$  if searched. Denote the payoff from committing H as  $v_H(c, r)$  if not searched, and  $-j_H(c, r)$  if searched. Let  $G_H$  and  $G_L$  denote the events that a motorist is guilty of offenses H and L, respectively, and let  $D_H$  and  $D_L$  be the guilt probabilities for each offense. As before, the payoff from not carrying is zero, whether or not the motorist is searched. Also as before, let  $\gamma(c, r)$  be the probability of search chosen by the police, given that the motorist is observed, and let  $m$  be the probability of being observed. Once again, we assume that  $c \in \{0, 1\}$  for expositional convenience (although the intuition carries through to the case where  $c$  is continuous).

When there are offenses of differing severity, it seems natural to assume that the benefits derived by the police from arresting motorists for each offense are different. That is, it appears likely that (normalizing the return from an arrest for H to 1) the return from an arrest for L would be  $b$ , where (typically) one would expect that  $b \in (0, 1)$ . However, under these assumptions, it is very difficult to find any testable restrictions on the data that are implied by the absence of police prejudice. In particular, the test employed by KPT is invalid, even in those circumstances identified below (as equilibrium 1a-b) where it remains valid under the assumption that  $b = 1$ .<sup>9</sup> Thus, in order to preserve at least some possibility that the KPT is valid, we maintain for now the assumption that the police receive equal returns from arrests for each offense. In the next section, we discuss the implications of relaxing this assumption, in the light of our empirical results.

Consider a motorist of given type  $(c, r)$ : she can choose any of the following classes of mixed strategies – (i) play N, (ii) play L, (iii) play H, (iv) randomize between N and L, (v) randomize between N and H, (vi) randomize between L and H, (vii) randomize between N, L, and H. Clearly, there are many possible cases, even when  $c$  is assumed to be binary. However, given the assumptions above, it is possible to eliminate most of these cases. For example, consider the class of equilibria where some type(s) randomize over L and H. Recall that equilibria exist where motorists randomize, for instance, between N and L because for any given set of parameter values, there exists a search probability for which the motorist is indifferent

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<sup>9</sup> In part of their empirical analysis, KPT assume, in effect, that  $b = 0$ ; under this assumption, their test is valid if all types of motorists are randomizing. However, the validity of their test does not extend to the case where  $b$  is strictly positive.

between N and L. In contrast, as a motorist who randomizes over L and H will always carry some quantity of drugs, the police will not adjust their behavior in response to the randomization, instead simply setting  $\gamma = 1$  (i.e. the unconditional probability of search =  $m$ ). A type  $(c, r)$  will randomize between L and H if:

$$(1 - m)v_H(c, r) - mj_H(c, r) = (1 - m)v_L(c, r) - mj_L(c, r) \quad (3)$$

The underlying parameter spaces for  $m$  and for the motorists' payoffs (the  $v$ 's and  $j$ 's) are continuous. Thus, it is clear that the condition above can only hold for a subset of the parameter space that is of measure zero – for generic parameter values, equilibria where some type(s) randomize over L and H can be ruled out. This argument can also be extended to equilibria where some type(s) randomize over N, L and H: for generic parameter values, these cases should collapse to randomization over either N and L or over N and H.

The possible equilibria can be further restricted by imposing a requirement of consistency with the basic features of the observed data. The data suggest that both offenses were committed in equilibrium by members of each race. Thus, equilibria in which neither crime, or only one kind, is committed can be ruled out as being inconsistent with the observed data. We also continue to restrict attention to equilibria in what we term “racially symmetric” strategy profiles. These are strategy profiles for which the following is true: for any given  $c$ , types  $(c, A)$  and  $(c, W)$  play the same class of strategy (note that this does *not* require that, for mixed strategies, the two races have to mix with identical probabilities). As discussed earlier, non-symmetric strategy profiles are also inconsistent with the observed data.

We are thus left with the following six cases to consider. They are grouped in symmetric pairs (noting that the labeling of types as  $c = 0$  and  $c = 1$  is arbitrary):

**Fully Randomizing Equilibria:**

**1a)** For each  $r$ , motorists of type  $(0, r)$  randomize between N and H (i.e. choose  $P^*(G_H | 0, r) \in (0, 1)$  and  $P^*(G_L | 0, r) = 0$ ), while motorists of type  $(1, r)$  randomize between N and L (i.e. choose  $P^*(G_L | 0, r) \in (0, 1)$  and  $P^*(G_H | 0, r) = 0$ ); the police set  $\gamma^*(0, r) \in (0, 1)$  and  $\gamma^*(1, r) \in (0, 1)$

**1b)** For each  $r$ , motorists of type  $(0, r)$  randomize between N and L (i.e. choose  $P^*(G_L | 0, r) \in (0, 1)$  and  $P^*(G_H | 0, r) = 0$ ), while motorists of type  $(1, r)$  randomize between N and H (i.e. choose  $P^*(G_H | 0, r) \in (0, 1)$  and  $P^*(G_L | 0, r) = 0$ ); the police set  $\gamma^*(0, r) \in (0, 1)$  and  $\gamma^*(1, r) \in (0, 1)$

Assuming one of these types of equilibria prevails, one can test for prejudice simply by comparing probabilities of guilt (of each offense) for each race. This is essentially the test that KPT implement. However, this is not a valid test if the observed data is generated by equilibrium behavior other than that of case 1a-b).

**Equilibria with Randomization over Low-level Offenses:**

**2a)** For each  $r$ , motorists of type  $(0, r)$  randomize between N and L (i.e. choose  $P^*(G_L | 0, r) \in (0, 1)$  and  $P^*(G_H | 0, r) = 0$ ), while motorists of type  $(1, r)$  play H (i.e. choose  $P^*(G_H | 0, r) = 1$  and  $P^*(G_L | 0, r) = 0$ ); the police set  $\gamma^*(0, r) \in (0, 1)$  and  $\gamma^*(1, r) = 1$

**2b)** For each  $r$ , motorists of type  $(0, r)$  play H (i.e. choose  $P^*(G_H | 0, r) = 1$  and  $P^*(G_L | 0, r) = 0$ ), while motorists of type  $(1, r)$  randomize between N and L (i.e. choose  $P^*(G_L | 0, r) \in (0, 1)$  and  $P^*(G_H | 0, r) = 0$ ); the police set  $\gamma^*(0, r) = 1$  and  $\gamma^*(1, r) \in (0, 1)$

Here, a subset of motorists (identifiable to the police but not to the econometrician) are playing a strategy of always carrying a large quantity of drugs (i.e. committing H). For these motorists, a comparison of probabilities of guilt across races will not be informative about police prejudice. This is because, by assumption,  $t_W, t_A \in (0, 1)$ ; hence,  $\gamma^*(c, W) = \gamma^*(c, A) = 1$  is consistent with any admissible  $t_W$  and  $t_A$ . In this setting, a valid test for prejudice requires omitting all observations where a motorist is found guilty of H, and testing for the equality of probabilities of guilt (of offense L) for the remaining sample.

### Equilibria with Randomization over High-level Offenses:

**3a)** For each  $r$ , motorists of type  $(0, r)$  play L (i.e. choose  $P^*(G_L | 0, r) = 1$  and  $P^*(G_H | 0, r) = 0$ ), while motorists of type  $(1, r)$  randomize between N and H (i.e. choose  $P^*(G_H | 0, r) \in (0, 1)$  and  $P^*(G_L | 0, r) = 0$ ); the police set  $\gamma^*(0, r) = 1$  and  $\gamma^*(1, r) \in (0, 1)$

**3b)** For each  $r$ , motorists of type  $(0, r)$  randomize between N and H (i.e. choose  $P^*(G_H | 0, r) \in (0, 1)$  and  $P^*(G_L | 0, r) = 0$ ), while motorists of type  $(1, r)$  play L (i.e. choose  $P^*(G_L | 0, r) = 1$  and  $P^*(G_H | 0, r) = 0$ ); the police set  $\gamma^*(0, r) \in (0, 1)$  and  $\gamma^*(1, r) = 1$

This represents the case where a subset of motorists always carry a small quantity (i.e. commit L). Thus, a valid test for prejudice requires omitting all observations where a motorist is found guilty of L, and testing for the equality of probabilities of guilt (of offense H) for the remaining sample.

## 4) Empirical Analysis

The data used by KPT were collected as part of a lawsuit settlement between the ACLU and the Maryland State Police. The settlement required the state to maintain detailed records on motorist searches and to file quarterly reports with the court and the ACLU. The data contains 1,590 observations on all motor vehicle searches on a section of Interstate 95 in Maryland. The data provide information on the race and gender of the driver; the make, model, and year of the automobile; date, time, and location of the search, and finally whether any controlled substances are found and if found the amount and type.<sup>10</sup>

Our model differs from KPT in two ways: 1) Police do not always observe potential offenders and as a result some types may offend with certainty, and 2) Potential offenders choose between two levels of offense and different types may separate over these offense levels. The empirical tests arising from these extensions suggest stratifying the sample by guilt severity for those that offend.<sup>11</sup> Therefore, the first task of this paper is to choose a stratification of offenses.

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<sup>10</sup> After obtaining permission from the Maryland Chapter of the American Civil Liberties Union, John Knowles provided us with the complete sample used in KPT.

<sup>11</sup> It should be noted that our empirical analysis focuses on the case where there are multiple levels of offenses, as well as imperfect observability. When the offense is homogeneous, and imperfect observability may lead to equilibria with some nonrandomizing agents, a valid test for prejudice is not available given the data limitations. In particular, information about the distribution of  $c$  across races is required. The multiple level of offense extension addresses this problem by providing predictions about sorting over offense type that can be used to infer information about  $c$ .

In their empirical analysis, KPT apply increasingly more stringent definitions of guilt starting with any controlled substance (Guilt 1), eliminating offenses involving amounts marijuana less than 2 grams (Guilt 2), eliminating offenses involving marijuana only (Guilt 3), and finally only considering offenses involving felony amounts of contraband. Using these definitions of guilt, KPT found no evidence of racial prejudice against African-Americans. Guilt frequencies were nearly identical for white and African-American motorists over all offenses, and after dropping offenses involving small quantities of marijuana they found higher rates of guilt among African-Americans suggesting reverse discrimination by state police.

Table 1 presents a similar breakdown of offenses. The sample contains 1473 searches of white and African-American motorists of which 1007 or 68 percent are of African-American motorists. The first two columns show the distribution of searches by race over offense category. The first row is the fraction of searches for which no contraband was found. The next three rows represent the fraction of searches where misdemeanor offenses were identified involving small amounts of marijuana, larger, non-felony amounts of marijuana, and hard drugs, respectively. The final category shows the fraction of searches locating felony amounts of contraband.

The racial pattern of offenses is striking. Although no racial differences in the likelihood of guilt exist overall, African-Americans are more likely to be guilty of felonies, and whites have higher guilty rates on misdemeanors for any of the three offense categories. Columns three and four show the frequency of guilt divided between misdemeanors and felony. African-Americans have a 6 percentage point lower guilty rate for misdemeanors overall and a 9 percentage point higher guilty rate for felonies. Racial differences in the pattern of guilt are statistically significant with less than a 0.001 chance of error for both the modified KPT categorization and the categorization of offenses into felony and non-felony.

Our theoretical analysis suggests that KPT's strategy of simply dropping low level offenses is not necessarily an appropriate way to handle offense heterogeneity. In fact, the identification of an appropriate strategy depends upon the type of equilibrium arising in the economy. Under the assumptions that equilibria 1a-b hold, where all types randomize, and that the police return to identifying guilty motorists does not vary by level of guilt, the appropriate test is the primary test provided by KPT where overall frequencies of guilt are compared for white and African-American motorists. Table 2 Panel A shows the results for these tests overall and by gender. African-Americans have a three percentage point higher guilty rate overall, but

the difference is not statistically significant. No meaningful racial difference exists in the frequency of guilt for African-American males, but a 22 percentage point difference in guilty rates, which is statistically significant at the 2 percent level, for females suggests prejudice against white females or reverse discrimination.

On the other hand, if equilibria 2a-b or 3a-b are assumed to describe the behavior of motorists and police, one type of motorist will randomize and the other type will offend with certainty. Under these circumstances, the correct strategy is to compare frequency of guilt after dropping the type that offends with certainty, which can be accomplished by simply dropping the offense level that is chosen by the type that offends with certainty. In equilibria 2a-b, some types of motorists commit high level offenses or felonies with certainty while in equilibrium 3a-b, some types commit low level offenses with certainty. In each of these equilibria, some types randomize, and an unbiased test for prejudice can be obtained from a sample consisting only of these types. For equilibria 2a-b, since certain types commit high level offenses with certainty, those types are never not guilty or guilty of low level offenses, a sample consisting only of those types that are randomizing is obtained by dropping those that are guilty of high level offenses. Similarly, a sample consisting only of those types that are randomizing is obtained in equilibria 3a-b by dropping those guilty of low level offenses.

Panels B and C of Table 2 show the results for these alternative tests of prejudice. If some types commit high level infractions or felonies with certainty (equilibrium 2a-b), whites have a 4 percentage point higher rate of guilt overall, but this result only exhibits very weak statistical significance at the 12 percent confidence level. It should be noted, however, that this difference represents a 7 percentage point change in the guilt frequency differences when compared to the results from panel A. For equilibria 3a-b, whites have a 13 percentage point lower guilty frequency, providing evidence of reverse discrimination with a high level of statistical significance. The shift from equilibria 1a-b to equilibria 3a-b also shifts the estimated difference by 7 percentage points, but in the opposite direction as the shift to equilibria 2a-b. While formal approaches do not exist to compare estimates across potential equilibria, these seven percentage point differences are quite meaningful given that KPT and this paper often find racial differences of 5 to 6 percentage points to be statistically significant.

This stratification also affects the empirical implications for the male and female subsamples. For the male subsample, the differences increase to 5 percentage points and are



statistically significant at the 6 percent level. Racial differences for the female subsample falls to 9 percentage points and are not statistically significant. On the other hand, for equilibrium 3a-b), whites have a lower rate of guilt overall and in both the male and female subsamples with differences ranging between 10 and 24 percentage points, and these results are statistically significant at better than the 0.1 percent level.

Clearly, the interpretation of data depends strongly on assumptions concerning the form of equilibria. An assumption that equilibrium 2a-b holds reverses the findings of no prejudice against African-American males and eliminates the finding of prejudice against white females. On the other hand, the results for equilibrium 3a-b imply the exact opposite finding reverse discrimination against white males and maintaining the finding of reverse discrimination against white females.

In an attempt to shed more light on these issues, we continue our empirical analysis in order to examine whether some additional forms of equilibria can be ruled out by the data. Specifically, the supplementary analysis considers variables in the sample that might provide a proxy for the police's assessment of a potential offenders return to offending ( $c$ ). Based on the theoretical model, any variable that is correlated with the return to offending will be correlated with offenders' level of guilt. The level of guilt comparison must be made conditional on the guilt of individual searched in order to assure that the proxy variables are chosen based on their relationship with offense level rather than a relationship with the likelihood of guilt.

Two such variables are vehicle type, which is divided between vehicles that are owned by the motorist and those that are owned by a third-party, and time of day, which is divided between the periods of 6 AM to 4 PM (workday) and 4 PM to 6 AM (other times). The fraction of all offenses that are felonies are 35 percentage points higher for third-party than owned vehicles and almost 10 percentage points lower for the workday period than the rest of the day. Both differences exhibit a high level of statistical significance (see Table 3).

Table 3 also shows the fraction guilty and the fraction African-American by both vehicle type and time of day. While guilt frequencies do not vary by vehicle type, the frequency of guilt is more than 5 percentage points lower during the workday, and the differences are statistically significant at the 2 percent level. This finding is not consistent with either the KPT model nor with a fully randomizing equilibrium in our model. These differences can only be explained if either some types offend with certainty or the police return to search varies by type of offense.

Finally, both of these proxy variables are highly correlated with race. In the sample of searched vehicles, third party vehicles are 18 percentage points more likely to be driven by African-American motorists as compared to vehicles that are owned by the motorists. Similarly, searches that are conducted during the workday period are 9 percentage points less likely to involve African-American motorists.

Table 4 presents additional tests under the assumption that either equilibria 2a-b or 3a-b hold and that either vehicle type or time of day provides a reasonable proxy for the potential offender type that determines both offender and police search behavior. Stratification by the proxy variable should shift the proportion of the sample either away from or towards types who offend with certainty and as a result either reduce or increase the bias in the traditional KPT test for prejudice. For vehicle type, the own vehicle sample should have lower bias under equilibrium 2a-b than the unconditional guilt frequency test of KPT, and the third-party sample should have lower bias under equilibrium 3a-b.

The results provide a partial confirmation of the findings in Table 2. The own-vehicle sample does not provide any evidence of prejudice against African-Americans as was found in Table 2 for equilibrium 3. The third-party sample, however, identifies a 13 percentage point higher rate of guilt for African-Americans, which is consistent with the Table 2 results for equilibrium 4 and implies reverse discrimination against whites. Of course, the test for equilibrium 3 may have weak power because the own vehicle subsample contains most of the overall sample and the fraction of felony offenses only fell by about 6 percentage points from 28 in the full sample to 22 in the own vehicle subsample. On the other hand, the fraction of felony offenses is almost 30 percentage points higher in the third-party vehicle than in the overall sample.

The results for the time of day variable, however, are quite at odds with the previous findings from Table 2. African-Americans are 7 percentage points more likely to be guilty in workday sample, which should have reduced bias under equilibrium 2a-b; and 5 percentage points less likely to be guilty in the other time sample, which should have reduced bias under equilibrium 3a-b. The racial differences are only statistically significant for the workday sample, but regardless the results imply reverse discrimination against whites for equilibrium 2a-b and at least suggest prejudice against African-Americans for equilibrium 3a-b. On the other hand, Table 2 provided strong evidence of reverse discrimination under the assumption that

equilibrium 3a-b held, as well as some evidence of prejudice under equilibrium 2a-b. Conditional on the earlier assumptions in the model, this contradiction suggests that the data is not consistent with equilibria where some types offend with certainty.

In summary, the results for own vehicle do not provide any more information than Table 2. Guilt frequencies do not vary across vehicle type, which is consistent with the assumptions of equilibria where all types randomize and of equal returns to police across offense types. The stratification analysis is also broadly consistent with the findings in panels B and C after accounting for the weak power provided by the own vehicle subsample. Therefore, vehicle type does not allow us to rule out any of the equilibria considered in the paper.

On the other hand, given the maintained assumptions in the model, the results for time of day are inconsistent with all of the equilibria forms considered. Equilibria 1a-b are rejected because guilty rates are not equal across the time of day variable that is clearly observable to police. Equilibria 2a-b and 3a-b are rejected because the analyses in Tables 2 and 4 are contradictory. If the behavior of agents is described by either equilibria 2a-b or 3a-b, Table 2 provides unbiased tests for prejudice, and the stratification by time of day in Table 4 should reduce the magnitude of the bias in the test relative to the KPT test based on unconditional guilt frequencies. This stratification produces racial differences in guilt that are further away from the Table 2 Panel B and C estimates as compared to the KPT estimates in Panel A. These findings suggest that one or more of the maintained assumptions in the theoretical model are incorrect.

One assumption imposed in the multiple offense level model is that the return to police is the same across offense types. Guilt rates are over 5 percentage points lower during the workday. This finding can be explained if return varies by offense type. The finding, however, is consistent with a model where police accept a lower frequency of successful searches, guilt rate, during the workday in exchange for higher return from the offense type that is more common during the workday. Therefore, the empirical relationship between time of day and guilt can only be explained by differences in the return to offense type if we accept the counter-intuitive implication that police value misdemeanor arrests more than felony arrests.

Another alternative explanation might involve the assumption that the cost of search is not same between workday and other times. Specifically, in order to be consistent with the findings, the cost of search would have to be lower during the workday and as a result police accept in equilibrium both lower rates of felony arrests and lower rates of guilt overall from

those searches. This assumption appears more reasonable than the higher return to misdemeanors assumption. In fact, the frequency of guilt does not differ by type of vehicle, which is predicted by the model if separate randomizing equilibria exist during the workday and other times. Nonetheless, identifying appropriate interpretations of these findings is dramatically more problematic under the possibility that both search costs may vary over observables and returns to arrests vary by type of offense.

## **5) Conclusion**

This paper seeks to contribute to the literature on performance-based measures of discrimination. In particular, we have reexamined the theoretical and empirical framework developed by Knowles, Persico and Todd (2001) to analyze racial bias in motor vehicle searches. We have generalized the KPT model to account for the possibility that potential offenders are not always observed by the police, and by including two different levels of offense severity. While these extensions are quite straightforward, they lead to the existence of multiple types of equilibria, including some in which potential offenders do not randomize, but rather offend with certainty. The validity of KPT's simple empirical test for prejudice depends crucially on which of these types of equilibria prevail, as well as on a number of other maintained assumptions. Our empirical analysis shows that the data used by KPT (on motor vehicle searches in Maryland) is consistent with prejudice against African-American males, with no prejudice, and with reverse discrimination, depending on which equilibrium is being played. Additional analysis using the time of day that searches were carried out casts doubt on the consistency of the data with any of these equilibria and/or with the maintained assumptions of the model.

The theoretical model in Knowles, Persico, and Todd (2001) is elegant and appears to offer a simple solution to the very difficult problem of omitted variables bias in analyses of discrimination in policing. Their model also might have formed the basis for resolving debates concerning the existence of discrimination in other markets, such as the labor or mortgage markets. The results presented above suggest, however, that theory is unlikely to solve the omitted variables problem often associated with tests for racial prejudice and discrimination in law enforcement or in any other markets. An alternative solution to these problems is to determine the factors considered by police during their patrols and undertake efforts to generate information on the distribution of these attributes in the relevant population of motorists.

Potential strategies for gathering such information might include the use of traditional trip diaries (Scott and Kanaroglou, 2002) or random monitoring of roadways to record the incidence of factors that might lead to police stops.

More recent work by Persico (2002) suggests that even when the randomizing equilibrium studied by KPT exists, it may not lead to a socially optimal outcome in terms of minimizing crime. The underlying assumption about police behavior is that it involves maximizing the probability of arrest (i.e. the number of successful searches), rather than minimizing the amount of crime. Hence, the search intensities for each race are chosen by the police to equate guilt rates, and are independent of the elasticities of crime to police auditing.<sup>12</sup> Thus, Persico argues that if W's are more responsive to policing than are A's, there is no conflict between the goals of greater fairness (i.e. reducing disparities in the search probabilities across races) and crime minimization. While the basic intuition of Persico's results may be robust to extensions of the model, both the theoretical and empirical analysis in this paper suggests that an evaluation of the efficiency of reducing racial disparities in search requires consideration of many more factors than just the elasticity of crime.

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<sup>12</sup> This feature pertains specifically to the model in Persico (2002), and does not apply to the broader KPT framework.

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Table 1: Guilt Probabilities by Race				
Definitions of Guilt	KPT's Offense Categories		Misdemeanor vs. Felony	
	Black	White	Black <sup>1</sup>	White
Not Guilty	66.1	69.1	66.1	69.1
Small Amount	7.9	9.9		
Marijuana Only	10.9	13.9	21.9	27.9
Hard Drugs	3.1	4.1		
Felony	12.0	3.0	12.0	3.0
Sample Size	466	1007	466	1007
Chi-Square Test	<0.001		<0.001	
1. The entry in the third row contains the faction of all non-felony offences.				

Table 2: Tests for Prejudice by Type of Equilibrium			
	Full Sample	Male Subsample	Female Subsample
Panel A: Everyone Randomizes - KPT (Equilibria 1a-b)			
White Fraction Guilty	30.9	31.8	22.0
Black Fraction Guilty	33.9	33.1	44.0
Chi-Square Test	0.261	0.640	0.018
Panel B: Felonies Committed with Certainty (Equilibria 2a-b)			
White Fraction Guilty	28.8	29.6	20.0
Black Fraction Guilty	24.8	24.6	28.8
Chi-Square Test	0.122	0.056	0.322
Panel C: Misdemeanors Committed with Certainty (Equilibria 3a-b)			
White Fraction Guilty	4.2	4.3	3.0
Black Fraction Guilty	15.2	14.4	27.6
Chi-Square Test	>0.001	>0.001	0.004
Sample Size	1473	1357	116



Table 3: Offense Type, Guilt, and Race Frequencies by Observable Attribute				
	Vehicle Type		Time of Day	
	Own	Third-Party	Workday	Other Times
Share of Observations	82.1	17.9	52.8	47.2
Sample Size	1209	264	778	695
Fraction Felony Offenses	21.7	57.1	23.0	32.4
Chi-Square Test	>0.001		0.021	
Fraction Guilty	33.2	31.4	30.2	35.8
Chi-Square Test	0.588		0.022	
Fraction Black	65.1	83.3	64.0	73.2
Chi-Square Test	>0.001		>0.001	

Table 4: Tests for Prejudice based by Observable Attributes				
Definitions of Guilt	Type of Vehicle		Time of Day	
	Own Vehicle	Third-Party	Workday	Other Times
White Fraction Guilty	32.0	20.5	25.7	38.7
Black Fraction Guilty	33.8	33.6	32.7	33.8
Chi-Square Test	0.524	0.086	0.041	0.338