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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.

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

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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 note 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. We show that the data is consistent with prejudice against African-American males, no prejudice, and reverse discrimination, depending on the type of equilibrium that exists. 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.

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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).¹ 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 team performance. Berkovec, Gabriel, Canner, and Hannan (1998, 1994) examine racial differences in default and find no evidence of prejudice-based discrimination. Ross (2002) and Ross and Yinger (2002, Chapter 8) argue that performance approaches suffers from the same omitted variable bias as direct examinations of treatment, but that the bias works in the opposite direction.²

Knowles, Persico and Todd (2001) make an important contribution to the methodological debate over using performance as a test for discrimination. They develop a model of strategic behavior by police (in their choice of motorists to search) and motorists (in their decision to carry

¹ Similarly, Ayres (2000) finds that African-Americans were 14 percent of the population and received 23 percent of citations and that African-American motorists were 4 times as likely to be arrested in Tulsa during the period June 1995 - June 2000. Also see Borooah (2001) for similar evidence based on traffic stops in England.

² Moreover, in the case of the default approach, Ross (2002) and Ross and Yinger (2002, Chapter 8) argue that the 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. In addition, they argue that these approaches cannot capture statistical discrimination, see Borooah (2001) for a discussion of statistical discrimination in the context of racial bias in policing.

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). KPT use a dataset on police stops along Interstate-95 in Maryland during the period January 1995 - January 1999, collected by the Maryland ACLU in connection with a lawsuit against the state. They conclude that the data is not consistent with the hypothesis of racial prejudice against African-Americans. This finding has been influential in the debate on the existence of racial profiling in the United States and elsewhere.³

The KPT model addresses the classic concern about omitted variable bias that arises with both performance based and adverse treatment based studies of discrimination. Intuitively, 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 to be searched if they do not adjust their behavior. This randomizing equilibrium breaks the link between the expected return to an action and the observed frequency of that action, and thus between the observed frequency and the unobservable individual attributes that are correlated with the expected return. Such logic might also be applied 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 (Besanko and Thakor, 1987; 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 do not randomize), and by including two different levels of offense severity.⁴ Multiple types of equilibria exist in a model where offenders may not be observed by the police, and the test applied in KPT only provides a valid test for prejudice for equilibria where all potential offenders randomize. Furthermore, using the model with imperfect observation and two offense levels, this paper develops valid tests for prejudice for each equilibria considered. This analysis 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

³ See e.g. Borooah (2002), Gross and Barnes (2002), and Dominitz (2003).

⁴ Persico (2002) extends the KPT model in a number of directions, but does not deal with the particular issues that we focus on.

equilibrium is being played. 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 and in other contexts.

The remainder of the paper is organized in the following manner. Section 2 below briefly reviews the basic model from KPT. Sections 3 and 4 present the model extensions and empirical analyses, respectively. Section 5 concludes.

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.

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.⁵ Thus, KPT analyze a mixed-strategy equilibrium, where motorists randomize over whether to carry drugs, and the police randomize over whether to search. In the simple case where c (like r)

⁵ 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.

is binary (say, $c \in \{0, 1\}$, which, as will be explained below, does not involve any significant loss of generality, 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.

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

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). The observability 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.⁶ We reinterpret the probability of search $\gamma \in [0, 1]$ as the probability that the police search a motorist, *conditional* on observing her. Thus, even if the police always search a given type contingent on observing that type (i.e. set $\gamma = 1$ for that type).

⁶ 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, and therefore m may be quite small in practice.

the highest feasible *unconditional* probability of search is m , which is less than one and allows for pure strategy equilibria.

Specifically, if the motorist is observed (with probability m), then she faces a γ 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:

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

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 γ . 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.

It should be noted that an offender choosing to offend with certainty does *not* entail that they always carry drugs. Rather, the crucial issue is whether they randomize or not. Offenders have a personal life and a business life; those who are not willing to randomize for any feasible γ will always choose to carry drugs when going about their business. Thus, for example, such an offender whose business activities involve transporting drugs from New York City to Baltimore will not undertake business trips between these cities sometimes randomly carrying drugs and at other times not doing so. However, even such an individual may not carry drugs while going about their personal life.

Our seemingly minor change in assumptions has quite drastic consequences for the equilibrium, and for the validity of KPT's test for prejudice. 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).⁷

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).⁸ Given these assumptions, we can characterize the following equilibrium:

- 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. The KPT test for prejudice remains valid only if the distribution of types is identical across races. For instance, suppose that

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

(so that a larger fraction of A’s (relative to W’s) are “dealers”). In the equilibrium specified above, $P^*(G | 1, \cdot) = 1$ 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,

⁷ Note that we focus on “racially symmetric” strategy profiles. Alternatively, 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.

⁸ 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 $(t_W/m) < 1, (t_A/m) < 1$.

as $c = 0$ types of both races are randomizing, the KPT argument applies: if $t_W = t_A = t$, then it follows that $P^*(G | 0, W) = P^*(G | 0, A) = t$.

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.

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.

KPT (p. 214) also offer an alternative (and more realistic) interpretation of their model, in which motorists do not randomize in equilibrium. Rather, they have private information (unobservable to the police) concerning their utility from carrying drugs. Within a particular observable category (i.e. a given c), some motorists will choose to carry and others to not do so, depending on their unobservable preference parameter (which can be modeled as a "random utility" term). Because the random utility realization is not observed by the police, the motorists are, in effect, randomizing from the perspective of the police. Thus, the KPT empirical test remains valid under this interpretation (noting that no type of c can consist entirely of motorists who always carry, because this type would then be searched with probability 1).

Our extension also applies to this version of the KPT model. With imperfect observability, it becomes possible that the preference parameters of all motorists within a given observable category (e.g. $c = 1$) are such that all these motorists would carry drugs. This may seem unlikely in the case where c is binary, but it should be remembered that this is a simplification for expositional convenience. When the number of types of c is large, or c is a

continuum, then it is reasonable to suppose that there may exist some types of c within which all motorists offend.

3.2) Offense Severity

In this section, we retain the assumption of imperfect observability, and 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. For this extension, potential offenders sort over low and high severity offenses. For equilibria involving non-randomizing offenders, offense severity can be used to restrict the sample to randomizers, providing valid tests for prejudice.

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.⁹ 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

⁹ Gross and Barnes (2002) provide evidence that African-American drivers are more likely to be guilty of serious offenses. They suggest that racial profiling by police may in fact be motivated by a desire to obtain convictions for these serious offenses. This evidence supports our assumption that police and criminal behavior is likely to vary by offense type.

identified below (as equilibrium 1) where it remains valid under the assumption that $b = 1$.¹⁰ Thus, in order to preserve at least some possibility that the KPT test is valid, we maintain the assumption that the police receive equal returns from arrests for each offense.

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 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 rule out equilibria where some type(s) randomize over N, L 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.¹¹

We are thus left with the following three cases to consider (noting that the labeling of types as $c = 0$ and $c = 1$ is arbitrary, and so can be interchanged in each case):

¹⁰ 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.

¹¹ 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.

Fully Randomizing Equilibria:

1) 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 $\gamma^*(1, r) \in (0, 1)$

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 1.

Equilibria with Randomization over Low-level Offenses:

2) 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 $\gamma^*(1, r) = 1$

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:

3) 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 $\gamma^*(1, r) \in (0, 1)$

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.

These tests are also useful for the generalization discussed above and by KPT where offenders have private information. Consider the case where the underlying return to carrying and the return to committing a High-level relative to a low level offense are both positively

related to the sum of c and an index representing the motorist's private information. Given the empirical fact that both offense types are observed, the threshold for carrying must be "below" the threshold between offense types. If the variance associated with private information is constant or even decreases c , motorist types who always carry (if these types exist) will be disproportionately represented among the sample of motorists who commit the High-level offense, and dropping motorists who commit the high level offense will mitigate the omitted variable bias. This selection strategy will also eliminate some members of the motorist types where not all members offend, but under the null hypothesis of no prejudice this selection does not alter racial differences in guilty rates.

4) Empirical Analysis

4.1) Reanalysis of Maryland ACLU Data

The data used by KPT were collected as part of a lawsuit settlement between the ACLU and the Maryland State Police.¹² 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 over the period 1995-1999.¹³

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.¹⁴ Therefore, the first task of this paper is to choose a stratification of offenses. 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

¹² KPT 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.

¹³ See KPT for further details.

¹⁴ 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, 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 .

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 all types randomize (case 1), 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 2 or 3 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 equilibrium 2, some types of motorists commit high level offenses or felonies with certainty while in equilibrium 3, 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 equilibrium 2, 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 equilibrium 3 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 2), 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 equilibrium 3, whites have a 13 percentage point lower guilty frequency, providing evidence of reverse discrimination with a high level of statistical significance. The shift from equilibrium 1 to equilibrium 3 also shifts the estimated difference by 7 percentage points, but in the opposite direction as the shift to equilibrium 2. 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 equilibrium. An assumption that equilibrium 2 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 3 imply the exact opposite finding reverse discrimination against white males and maintaining the finding of reverse discrimination against white females.

4.2) Follow-up Analysis

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 offender's 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. Note that 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 (equilibrium 1). 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 2 or 3 hold. 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 2 than the unconditional guilt frequency test of KPT because individuals who offend with certainty have been disproportionately eliminated from the sample, and similarly the third-party sample should have lower bias under equilibrium 3.

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 2; and 5 percentage points less likely to be guilty in the other time sample, which should have reduced bias under equilibrium 3. The racial differences are only statistically significant for the workday sample, but regardless the results imply reverse discrimination against whites for equilibrium 2 and at least suggest prejudice against African-Americans for equilibrium 3. On the other hand, Table 2 provided strong evidence of reverse discrimination under the assumption that equilibrium 3 held, as well as some evidence of prejudice under equilibrium 2. 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, given the maintained assumptions in the model, the results for time of day are inconsistent with all of the equilibria forms considered. Equilibria 1 are rejected because guilty rates are not equal across the time of day variable that is clearly observable to police. Equilibria 2 and 3 are rejected because the analyses in Tables 2 and 4 are contradictory. If the behavior of agents is described by either equilibria 2 or 3, 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.

Two assumptions imposed in ours and the KPT model are that the return to police is the same across offense types and that the cost of search is not same between workday and other times. Guilt rates are over 5 percentage points lower during the workday. This 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, misdemeanors, that are more common during the workday. Alternatively, if the cost of search is lower during the workday, police may rationally accept both lower rates of felony arrests and lower rates of guilt overall from those searches. This second 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 reexamines 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 analyses based on stratification by type of vehicle and time of day were conducted. The results from the time of day analysis are not consistent with the three equilibria considered and suggest that other model assumptions, such as constant search costs for all times of day, are violated.

Thus, while the theoretical model in KPT is elegant and appears to offer a simple solution to the very difficult problem of omitted variables bias in analyses of discrimination in policing, the results above suggest that theory is unlikely to solve the omitted variables problem often associated with tests for racial prejudice and discrimination in law enforcement and in other contexts. An alternative solution to these problems in racial profiling context 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.

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Table 1: Guilt Probabilities by Race				
Definitions of Guilt	KPT's Offense Categories		Misdemeanor vs. Felony	
	Black	White	Black ¹	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 (Equilibrium 1)			
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 (Equilibrium 2)			
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 (Equilibrium 3)			
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