What Can DNA Exonerations Tell Us About Racial Differences in Wrongful Conviction Rates?*

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Abstract: We show that data on DNA exonerations can be informative about racial differences in wrongful conviction rates under some assumptions regarding the DNA exoneration process. We argue that with respect to rape cases, the observed data and the plausibility of the required assumptions combine to strongly suggest that the wrongful conviction rate is significantly higher among black convicts than white convicts. By contrast, we argue that the ability of data on DNA exonerations to reveal information about racial differences in wrongful conviction rates for murder is much more limited.

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I - Introduction

There exists a substantial body of research evaluating whether particular justice systems, such as that of the United States, are racially biased. The vast majority of these studies have focused on racial bias with respect to policing and sentencing, but few have attempted to formally evaluate whether there exists any racial bias with respect to wrongful convictions. The likely reason for this is that it is simply not possible to know innocence or guilt with certainty for a substantial fraction of those convicted. However, there does exist one set of convicts for which we know innocence with near certainty---namely those who were convicted for a crime but later exonerated via DNA evidence of innocence. This paper attempts to determine what we can learn about racial differences in wrongful conviction rates from data on DNA exonerations.

A recently released report by the National Registry of Exonerations reveals that black Americans represent a disproportionate number of rape and murder exonerations relative to their share of the overall population (Gross, Possley, and Stephens 2017). While this has been taken as evidence that the rate of wrongful convictions is higher among black convicts than white convicts (Chokshi 2017; Martelle 2017), it is actually not a priori clear what this tells us about any racial differences in the relative frequency of innocent people being convicted for a crime in lieu of the actual perpetrator. We take a formal approach to this question, and show how regression methods employing data on DNA exonerations and number of convictions by state by year by race can be used to estimate a parameter that captures *the combination* of any racial differences in wrongful conviction rates for a given crime *and* any racial differences in the likelihood of a DNA exoneration among innocent convicts. We then show how our methodology allows us to back out the parameter of interest---namely the parameter that captures any difference in wrongful conviction rates by race---but only by making an assumption regarding the extent to which the likelihood of DNA exoneration among the innocent does or does not systematically differ by race.

The fundamental complication is that there is little direct evidence regarding whether the likelihood of DNA exoneration does or does not systematically differ across innocent convicts by race. However, an important benefit of our methodology is that it allows us to straightforwardly consider various assumptions regarding possible racial biases in the DNA exoneration process and see how such differing assumptions impact the conclusions one would make regarding racial differences in wrongful conviction rates.

With respect to rape, we show that under a relatively wide range of assumptions regarding possible racial biases in the DNA exoneration process (including no bias), our estimates suggest a significantly higher wrongful conviction rate among black convicts than white convicts. For example, if one believes that the likelihood of DNA exoneration among wrongfully convicted white defendants is generally similar to or greater than it is among wrongfully convicted black defendants convicted in the same year in the same state, then our results would imply that the wrongful conviction rate for rape among black convicts is over *two and a half times* higher than it is among white convicts. More broadly, our results reveal that for one to conclude the wrongful conviction rate for rape is not significantly higher among black convicts than white convicts, one would have to believe the likelihood of DNA exoneration among wrongfully convicted black convicts is over fifty percent higher than it is among wrongfully convicted white convicts convicted in the same state and same year.

Interestingly, our results for murder are differ substantially. In particular, we show that if one thinks the likelihood of a DNA exoneration among innocent defendants convicted in the same year in the same state is roughly similar across races, then our estimates would lead one to conclude that the wrongful conviction rate for murder is roughly equal across races. For one to conclude the wrongful conviction rate for murder differs significantly across races, one would have to believe that the likelihood of a DNA exoneration among innocent defendants of one race is over fifty percent higher than it is among innocent defendants of the other race convicted in the same year and same state.

Given these results, one is then left with the question---is there a strong racial bias in the DNA exoneration process? As we have stated above, we have little direct evidence on this matter. However, we consider one piece of evidence that indirectly speaks to racial biases in the DNA exoneration process. In particular, if one thought that the DNA exoneration process was somehow biased in favor of wrongfully convicted individuals from race A over those of race B, then one would expect that, on average, wrongfully convicted individuals from race A would be found and exonerated more quickly than wrongfully convicted individuals from race B. This would in turn mean that, among the exonerated, the average time to exoneration would be shorter among those from race A than race B. With respect to rape, we find time to exoneration slightly longer among black exonerees than white exonerees, though not significantly so. With respect to murder, we again find time to exoneration is longer among black exonerees than white exonerees, but in this case quite significantly so (over two years). Overall, this evidence regarding time to exoneration gives no evidence to suggest a racial bias in the DNA exoneration process in favor of black convicts, but is at least suggestive of a bias in favor of white convicts when it comes to murder.

In the end, we think our findings make a substantial step forward regarding an important question over which there is limited empirical evidence. In particular, our results provide relatively robust statistical evidence that the wrongful conviction rate for rape is substantially higher among black convicts than white convicts. Importantly though, our approach also reveals what type of new evidence could overturn this conclusion---namely evidence indicating that the DNA exoneration process very strongly favors innocent black defendants over innocent white defendants, but yet somehow does not cause the time to exoneration to be shorter among black rape exonerees than white rape exonerees---a tall, but not necessarily impossible order.

By contrast, our conclusions with respect to murder are quite different in nature. Our results reveal that one could conclude there exists a racial difference in wrongful conviction rates for murder only if one believes that the DNA exoneration process somehow very strongly favors one race over another. However, large racial biases in the DNA exoneration process arguably seem more plausible for murder cases than rape cases. In particular, for rape cases, DNA is very likely to be at the crime scene, and if tested, is likely to be exculpatory for someone who was wrongly convicted for that crime. Therefore, the primary hurdle to overcome in overturning a wrongful conviction for rape is determining whether any material containing DNA from the crime scene can be found and tested after conviction. On the other hand, for murder, the likelihood exculpatory DNA evidence exists is probably higher for some types of murders (e.g., rape-murders) than others (e.g., drive-by shootings). If there exist notable racial differences in the types of murders associated with the convictions of those wrongfully convicted (which is not something that is observable), then this might lead to a substantially higher likelihood of DNA exoneration among wrongfully convicted individuals form one race than another. And indeed, our analysis of time to exoneration is at least suggestive of substantial racial biases (in favor of whites) in the DNA exoneration process when it comes to murder. Therefore, in contrast to our findings with respect to rape, when it comes to murder, we think our analysis is more revealing of the constraints that arise in attempting to use data on DNA exonerations to make inferences about racial differences in wrongful conviction rates.

II - Background on Wrongful Convictions, Race, and DNA Exonerations

There exists a long list of writings documenting cases in which the wrong person was convicted for a crime in the U.S. (Huff and Rattner 1988; Protess and Warden 1998; Christianson 2004; Balko and Carrington 2018; to name just a few). The cases contained in the works above encompass only a fraction of all wrongful convictions, but make it clear that wrongful convictions are not just rare anomalies, but rather numerous enough to truly affect society's perceptions of the justice system.[1] Indeed, looking at exonerations among capital murder cases and doing some extrapolation, Gross et al. (2014) estimate that at least 6 percent of those sentenced to death were actually innocent.

Wrongful convictions in which the wrong person is convicted for a crime occur for a variety of reasons, including planted or misrepresented evidence (Boyer 2001; Joy 2006), coerced confessions (Kassin 1997; Leo and Ofshe 1998), lying informants (Zimmerman 2001; Stevenson 2014), or eyewitness

[1] There actually exist two classes of wrongful convictions. First, there are those in which an innocent person was convicted for a criminal act committed by another person. Second, there are those in which a person is convicted for an act, but this act is mis-specified (e.g., a person is convicted for murder, but the death was a result of an accident or in self-defense, or a person is convicted for rape but the act was consensual or actually did not occur). While there can be racial differences in both classes, DNA evidence can only speak to the former. Therefore, in what follows, when we speak of "wrongful convictions", we are referring to cases in which an innocent person was convicted in lieu of the person who actually committed the crime.

mistakes (Huff et al. 1996; Scheck et al. 2000). Moreover, even when the evidence is "true," errors can still occur, as such evidence often provides only imperfect information regarding defendant guilt.

Race and Wrongful Convictions

Given the discussion above, wrongful convictions may be more likely to arise with respect to members of one race than another for several reasons. First, the court process might be racially biased in that judges/juries are less averse to convicting innocent defendants of one race than another, or judges/juries hold stronger prior beliefs of guilt regarding defendants of one race relative to another. This could translate into holding members of one race to a lower evidence threshold for conviction than members of another race. Second, even if the court process is racially unbiased, wrongful conviction rates can be higher among convicts of one race than another if the likelihood of being falsely charged differs across races due to police or prosecutors employing a lower standard of evidence for determining when to charge individuals of one race relative to another, a greater likelihood of police or prosecutors planting or distorting evidence against individuals of one race relative to another, or because informants are more likely to lie or witnesses are more likely to be mistaken when defendants are of one race relative to another.

As alluded to in the introduction, while there is a large literature on racial bias in the judicial system, the vast majority of this work has focused on policing and sentencing.[2] The handful of studies looking at racial discrepancies in wrongful convictions have either focused on specific case studies (Parker et al. 2001), or looked at the characteristics, including racial composition, of a collection of exonerated defendants (Bedau and Radelet 1987; Huff et al. 1996; Radelet et al. 1996; Gross and O'Brien 2008). Harmon (2001) built on this literature by comparing the characteristics of a collection of

[2] Examples of studies looking at racial bias in policing include Knowles et al. (2001), Anwar and Fang (2006), Becket et al. (2006), Grogger and Ridgeway (2006), Ridgeway (2006), Gelman et al. (2007), and Antonovics and Knight (2009). See Ridgeway and MacDonald (2010) for an overview of much of this work. Examples of some studies looking at racial bias in sentencing include Steffensmeier et al. (1998), Spohn and Holleran (2000), Bushway and Piehl (2001), Johnson (2003), Blume et al. (2004), Mitchell (2005), Ulmer et al. (2011), Abrams et al. (2012), Rehavi and Starr (2014), and Kutateladze et al. (2014). These are just a few examples in a much broader literature.

exonerated convicts to a matched group of convicts who were not exonerated. Gross, Possley, and Stephens (2017) provide the most comprehensive look at the exonerated population to date and find that black defendants make up a far greater fraction of the exonerated population than they do of the United States population as a whole.

Harmon (2004) and later Alesina and La Ferrara (2014) extend this literature by focusing on capital murder convictions, and consider how the eventual fate of the defendant depends on the combination of the defendant’s and victim’s race. In particular, Alesina and La Ferrara (2014) argue that while the likelihood a conviction is overturned on statutory appeal may differ by race of the victim (possibly due to differences in circumstances of the crime that correlate with race of victim), any such difference should not differ by race of the defendant if the system is racially unbiased. However, they find that the likelihood a conviction is overturned on statutory appeal for non-white defendants is significantly higher when the victim is white than when the victim is non-white, but this is not true for white defendants (a finding also consistent with Harmon (2004)). Alesina and La Ferrara (2014) argue that this provides evidence of racial bias with respect to death penalty cases.

An important component of Alesina and La Ferrara’s (2014) empirical design is that all death penalty cases are automatically appealed, which means that among these cases, there can be no racial differences in which cases make it to an appeal in front of a judge. This mitigates a good deal of unobservable selection concerns. However, it is still possible that defense and/or prosecutor quality is systematically related to aspects of the case, including race of the defendant, race of the victim, or the combination of the two, meaning there might be some selection concerns regarding the strength of the appeal. Moreover, as Alesina and La Ferrara (2014) discuss, their procedure cannot distinguish between whether black defendants convicted for murdering white victims are more likely to be innocent than white defendants convicted for murdering white victims, versus whether black defendants wrongfully convicted for murdering white victims are more likely to be given the death penalty than white defendants wrongfully convicted for murdering white victims (for which there is some evidence, see Blume, Eisenberg, and Wells (2004)).

Therefore, while Harmon's (2004) and Alesina and La Ferrara's (2014) analyses offer important first steps in applying statistical rigor to understanding racial differences in wrongful conviction rates, we think it is important to continue building on this literature.

DNA Exonerations

DNA evidence was first used as evidence in a criminal trial in the United States in November 1987, and first used to exonerate a convicted felon in November 1989. Since then, innocent defendants who have been exonerated via DNA evidence have generally received legal assistance from groups such as the various Innocence Projects or law school clinics. The cases these organizations take up usually start with a letter from a convicted defendant or his family. Based on these letters and follow-up questionnaires, a determination is made regarding whether the case merits further investigation, which almost always hinges on whether DNA evidence could potentially be exculpatory. For example, the national Innocence Project says that it will only consider cases where

> "(t)here is physical evidence that, if subjected to DNA testing, will prove that the defendant is actually innocent. This means that physical evidence was collected – for example blood, bodily fluids, clothing, hair – and if that evidence can be found and tested, the test will prove that the defendant could not have committed the crime."(http://www.innocenceproject.org/submit-case)

According to Justin Brooks, Director of the California Innocence Project, and Carmichael and Caspers (2015), such criteria also holds true for the California Innocence Project and several wrongful conviction legal aid projects in Texas.

The obvious problem is that for many innocent convicts, exculpatory DNA evidence simply doesn't exist. In the end, it seems relatively clear that in order to obtain a DNA exoneration, not only must a motivated and competent advocate become involved with the case, but there must be a variety of other circumstances regarding the case---such as whether DNA evidence could be exonerative of the crime committed, whether such the evidence existed on the crime scene, and whether material containing this evidence was collected and effectively stored over time---that arguably seem unlikely to be related to the characteristics of the wrongfully convicted individual in question, particularly for those convicted prior to when DNA evidence started to be used in criminal courts circa 1988.

III –Uncovering Racial Differences in Wrongful Convictions Rates from DNA Exoneration Rates

We are interested in assessing whether *the wrongful conviction rate* for a particular crime (e.g., rape or murder) differs across races in the United States, where the *wrongful conviction rate* refers to the fraction of convictions for a given crime in which an innocent person was convicted for a crime in lieu of the actual perpetrator. Specifically, consider a population of C_r defendants of race r who have already been convicted for a given crime. Of this population, I_r are actually innocent of this crime for which they were convicted. Hence, the wrongful conviction rate among this population is

$$\pi_r = \frac{I_r}{C_r}.$$

While C_r is observable, clearly I_r is not, meaning the wrongful conviction rate π_r also is not, so one cannot directly observe whether the wrongful conviction rate for one race differs from the wrongful conviction rate for another race for any given crime.

However, suppose we can observe the number of defendants of each race r convicted for a given crime who have been exonerated by DNA evidence. The question of interest is to what extent can such data be used to recover information about the relative difference between the wrongful conviction rate among white convicts π_W and the wrongful conviction rate among black convicts π_B for this crime?

In considering this question, we will take it as a given that one must be innocent of the crime of conviction to be exonerated of this crime based on DNA evidence. However, as discussed above, not all wrongfully convicted defendants are exonerated due to DNA evidence. To be exonerated by DNA evidence there must have been DNA evidence at the crime scene, this evidence must have been collected and properly stored, this evidence must be exculpatory in the sense that it excludes the possibility that the wrongfully convicted defendant committed the crime, and such evidence must be heard and accepted by the court. Moreover, these processes might differ across states and time, and even within states, it is possible that this process may differ by race of defendant.

To model this, suppose that for any given wrongfully convicted defendant of race r in state s convicted in year t, the probability that exculpatory DNA evidence exists, is properly stored, and is presented and accepted by a court equals $p_{r,s,t}$. Therefore, the number of DNA exonerations of defendants of race r in state s convicted in year t for a given crime (denoted $e_{r,s,t}$) is a random variable with expected value

$$E[e_{r,s,t}] = p_{r,s,t}\pi_{r,s,t}C_{r,s,t}, \quad (1)$$

where $\pi_{r,s,t}$ and $C_{r,st}$ are the wrongful conviction rate and total number of individuals of race r in state s convicted in year t for the crime in question. Now, further suppose that the wrongful conviction rate among individuals of race r in state s convicted in year t is captured by the following parameterization

$$\pi_{r,s,t} = \exp\{\beta_1 black + \delta_s + \rho_t\},$$

where *black* is an indicator equaling one if race r corresponds to "black," and δ_s and ρ_t are state s and time t specific shift terms. Clearly, β_1 is the parameter of interest, as it captures the extent to which there are systematic racial differences in wrongful conviction rates across states and years for the crime in question.

Similarly, let us also suppose that the probability that a wrongfully convicted individual of race r in state s convicted in year t is exonerated by DNA evidence is captured by

$$p_{r,s,t} = \exp\{\beta_2 black + \varphi_s + \gamma_t\},$$

where again *black* is an indicator equaling one if race r corresponds to "black," and φ_s and γ_t are state s and time t specific shift terms. Under this formulation, β_2 captures the extent to which the likelihood of DNA exoneration among wrongfully convicted individuals differs systematically by race.

Given these formulations, equation (1) becomes

$$E[e_{r,s,t}] = e^{\beta_2 black+\varphi_s+\gamma_t}e^{\beta_1 black+\delta_s+\rho_t}C_{r,s,t}.$$

Taking the natural log of the above equation we get

$$lnE[e_{r,s,t}] = \beta_2 black + \varphi_s + \gamma_t + \beta_1 black + \delta_s + \rho_t + lnC_{r,s,t},$$

which can re-written as

$$(2) \qquad lnE[e_{r,s,t}] = \beta black + \alpha_s + \tau_t + lnC_{r,s,t},$$

where $\beta = (\beta_1 + \beta_2)$, $\alpha_s = (\varphi_s + \delta_s)$, and $\tau_t = (\gamma_t + \rho_t)$.

Given $e_{r,s,t}$ is a count variable, we can estimate the parameter β, and the parameters α_s for each state s, and τ_t for each year t, via a straightforward application of a maximum likelihood negative binomial regression. As equation (2) makes clear however, there exists a fundamental identification problem in that we can only estimate β, meaning the data by itself cannot separately identify our parameter of interest β_1, which constitutes the extent to which the wrongful conviction rate differs between black convicts and white convicts, from β_2, which captures the extent to which innocent black defendants are more or less likely than innocent white defendants to be exonerated via DNA evidence. This means that in order to identify β_1, we must make an assumption regarding β_2.

Given our discussion in Section II, we think one reasonable place to start is to assume $\beta_2 \approx 0$, or that innocent black and white convicts convicted in the same state and same year are roughly equally likely to be exonerated by DNA evidence. However, we do not have any specific evidence regarding this parameter and it is certainly possible that there is some way in which the DNA exoneration process favors innocent convicts from one race over the other. Therefore, in the empirical work to follow, we consider a variety of possible values for β_2 and then back out the implied value for β_1 from our estimate of β.

IV - Data

Data for this analysis come from two sources. First, data on exonerations come from the National Registry of Exonerations. This registry was co-founded by Samuel Gross (Professor of Law at the University of Michigan Law School) and Rob Warden (Executive Director Emeritus and co-founder of the Center for Wrongful Convictions at Northwestern University School of Law). The Registry has collected information about all known exonerations in the United States from 1989 to the present.

The Registry of Exonerations has documented well over 1,300 exonerations since 1989. For each exoneration, we know the exoneree's race, state where conviction occurred, conviction crime, year convicted, year exonerated, and whether DNA evidence played a role in the exoneration. As discussed above, for the purposes of this paper we are primarily interested in DNA exonerations, which we define as being cases in which a person has been convicted of a crime but is later pardoned, acquitted, or has his conviction dismissed based on DNA evidence of *innocence*. The Registry of Exonerations reveals that there have been 425 such DNA exonerations since 1989. Of note, 182 of these DNA exonerations related to murder convictions, 196 related to rape convictions, and only 47 were for any other type of crime. Therefore, we will analyze only rape and murder. [3]

Figure 1 tracks these DNA exonerations by conviction year cohort. The vast majority of DNA exonerations have been among defendants convicted between 1980 and 2000. The reasons for the relative dearth of DNA exonerations among those convicted post-2000 are likely twofold. First, DNA exonerations take time. Overall, among all of those exonerated by DNA evidence, the average time between conviction and exoneration was roughly 16 years. Clearly those convicted before 1989 could not be exonerated by DNA evidence right away. However, even among those convicted after 1989, the average time to exoneration was almost 12 years. Second, it is likely that testing DNA evidence prior to trial has become far more frequent over time, making wrongful convictions when there is testable DNA evidence less frequent.

Our convictions data come from the National Corrections Reporting Program (NCRP) (US Department of Justice 2014). This data set provides offender-level data on admissions to state prisons. Since all of the exonerated defendants in our exoneration data convicted for rape or murder were sentenced to prison, the population of defendants sentenced to prison for rape or murder is the relevant population for our analysis. The NCRP data is helpful in that the series is collected annually going all the way back to 1983 and has race data for most defendants (over 95 percent of murder and rape defendants).

[3] A handful of what we classify as DNA exonerations were exonerations in which, as stated by the National Registry of Exonerations, “other non-DNA factors were essential to the exoneration” (marked with an * in the database). Among our DNA exonerations for we use in our analysis for rape, only 2 had this caveat, while 39 of our DNA murder exonerations included this caveat. We include these exonerations in our study, but dropping them has a negligible impact on our results (estimates available upon request).

One limitation of this data is that Hispanic ethnicity is missing for many defendants, and even when reported, the documentation for these data suggest that there may be considerable reporting error with respect to Hispanic ethnicity. Therefore, we will only evaluate wrongful conviction rates across "black" and "white" defendants, where both racial categories are inclusive of Hispanic ethnicity.

In the end, we use this NCRP data in conjunction with the exonerations data to create an aggregated panel dataset where the unit of observation is state/conviction year/race, and each observation contains state and conviction year cohort identifiers, an identifier for whether the data corresponds to blacks or whites, the number of new convictions for rape and murder in that year in that state for that race, and the number of DNA exonerations among those convicted for both rape and murder in that year in that state for that race.

We employ the convictions and exonerations only among those cohorts convicted in the 15 year period between 1983 and 1997. The reason we limit our analysis to defendants convicted in this time period is that, as discussed above, it takes substantial time for DNA exonerations to move through the system (e.g., among eventual DNA exonerees convicted after the first DNA exoneration in 1989 but prior to 1996, the median time to exoneration was 11 years with the 90^{th} percentile being 19 years). Hence, by limiting our analysis to those convicted prior to 1998 we feel relatively confident that the vast majority of DNA exonerations that will occur with respect to these cohorts have already happened. Moreover, the vast majority of DNA exonerations have occurred among these cohorts (as seen in Figure 1).[4]

In developing the dataset for our wrongful conviction analysis for each crime, we first exclude any states in which there have been no DNA exonerations for that crime among the conviction cohorts we examine as such states cannot provide information to help identify any of our parameter of interest. We also have to deal with the fact that NCRP convictions data is not reported in some states in some years. Given the relative scarcity of DNA exonerations and time periods, we prefer to not throw these state/years with missing conviction years out. Therefore, to deal with these missing observations with respect to

[4] Results are essentially unchanged if we extend the conviction cohorts up to 2005. We haven't obtained the NCRP data beyond that point yet.

convictions, we do a simple linear interpolation based on actual convictions in that state for that crime before and after the year(s) in which data is missing.[5] As we discuss below, our results are robust to excluding states for which we had to interpolate much of the conviction data.

Table 1 shows which state/years are included in our rape and murder analyses respectively, as well as the number of these years for which we interpolated the number of convictions, and the total number of DNA exonerations in each state for each crime among the conviction cohorts in our analysis.

V - Results

Recall from Section III that our equation to estimate for each crime is

$$(2) \qquad lnE\left[e_{r,s,t}\right] = \beta black + \alpha_s + \tau_t + lnC_{r,s,t}.$$

Given the number of DNA exonerations among those of a given race convicted in a given year in a given state is a count variable, we estimate the parameters of equation (2) using standard maximum likelihood methods for estimating a negative binomial regression. Using the base dataset described above, our estimated β coefficient for rape is 1.01 with a standard error (clustered by state) of 0.24. By contrast, for murder, our estimated β coefficient is -0.29 with a standard error (clustered by state) of 0.36.

In order to interpret these estimated parameters, we have to make some assumptions and some transformations. As discussed earlier, our estimate of β equals $(\beta_1 + \beta_2)$, so our parameter of interest β_1 equals β - β_2. Therefore, to interpret what our estimated βs imply about racial differences in wrongful conviction rates, we consider the β_1's implied by our estimated β coefficients under different assumptions regarding the size of β_2. Also, for ease of interpretation, we present our varying assumptions and results in terms of incidence rate ratios (IRRs).

More specifically, suppose we start with the assumption that the likelihood of a DNA exoneration among innocent defendants convicted in the same year in the same state is similar across races. This

[5] For state/years where convictions for a given crime were missing, equaled zero, or equaled one, but there exists valid data on convictions for that crime in years preceding and years following, we used the "ipolate" command in Stata to interpolate the number of convictions for that crime in that year. We then allocated these convictions by race based on the average racial distribution of these convictions in that state for this crime in years in which there is valid data.

would correspond to a $\beta_2 = 0$, which is the same as saying the black/white DNA Exoneration IRR is equal to 1. If $\beta_2 = 0$, then $\beta_1 = 1.01 – 0 = 1.01$, which when exponentiated corresponds to a black/white wrongful conviction IRR of 2.74.[6] This implies that if one believes the likelihood of a DNA exoneration conditional on innocence, state of conviction, and year of conviction is equal across races, then the wrongful conviction rate for rape is over two and a half times higher among black convicts than white convicts. Furthermore, one can reject the null hypothesis that this IRR equals unity at beyond the one percent level.

By contrast, if one were to assume that the likelihood of a DNA exoneration is 25 percent more likely among innocent blacks than innocent whites convicted for rape in the same state in the same year (i.e., assume a black/white DNA exoneration IRR of 1.25), this would correspond to a $\beta_2 = 0.223$, implying $\beta_1 = 1.01 – 0.223 = 0.787$. This would in turn correspond to a black/white wrongful conviction IRR for rape of 2.20. While smaller, this still suggests the wrongful conviction rate among black defendants convicted for rape is over twice as high as it is among white defendants convicted for rape, and again we can reject the null hypothesis that the black/white wrongful conviction IRR equals unity at beyond the one percent level.

Figures 2a and 2b summarize the above process over a variety of assumptions regarding racial bias in the DNA process for rape and murder separately. On the horizontal axis in each figure we consider different levels of racial bias in the DNA exoneration process. The far left of the figures consider a DNA exoneration process where the IRR with respect to DNA exonerations among innocent black convicts relative to innocent white convicts convicted for the same crime in the same state in the same year is 0.5, or in other words, the assumption is that innocent black convicts are on average about half as likely as innocent white convicts to be exonerated by DNA evidence (this would correspond to a $\beta_2 = -0.693$). Moving right along the horizontal axes corresponds to a DNA exoneration process that is more and more

[6] To see this explicitly, note that given the setup in Section III, the black/white incidence rate ratio for wrongful convictions is $\frac{\pi_B}{\pi_W} = \frac{\exp\{(\beta-\beta_2)+\delta_t+\rho_t\}}{\exp\{\delta_t+\rho_t\}} = \exp\{\beta - \beta_2\}$. Therefore, if β = 1.01 and $\beta_2 = 0$, $\frac{\pi_B}{\pi_W} = \exp\{1.01 - 0\} = 2.74$.

biased in favor of innocent black convicts relative to innocent white convicts, with the far right end corresponding to an assumption that innocent black convicts are twice as likely to be exonerated by DNA evidence than innocent white convicts convicted for that crime in the same state in the same year. The vertical axis in each figure then shows the implied black/white IRR with respect to wrongful conviction rates associated with each assumed level of bias in the DNA exoneration process. The dark solid lines show the implied point estimates and the dashed lines capture the 95 percent confidence intervals associated with these point estimates. The shaded areas reveal where the point estimate differs from unity at the 5 percent significance level.

Looking first at our results with respect to rape as shown in Figure 2a, we again see that if one assumes that the likelihood of DNA exoneration is roughly equal between innocent black convicts and innocent white convicts (i.e., the black/white DNA exoneration IRR among the innocent is approximately equal to 1), then our estimated β of 1.01 implies a black/white IRR with respect to wrongful conviction rates for rape of 2.74. More broadly, the shaded area of Figure 2a shows that if one assumes that the likelihood of a DNA exoneration among innocent black convicts is anything less than 1.5 times higher than it is among innocent white convicts, then our estimated β would lead one to conclude that the wrongful conviction rate for rape is significantly higher among black convicts than white convicts.

By contrast, Figure 2b shows our results with respect to murder. If one again starts with the assumption that the likelihood of DNA exoneration is roughly equal between innocent black convicts and innocent white convicts (i.e., assume that the black/white DNA exoneration IRR equals 1), then our estimated β of -0.29 implies that the black/white IRR with respect to wrongful conviction rates for murder cannot be statistically distinguished from equaling 1. In other words, for murder, if one assumes the DNA exoneration process is essentially racially unbiased, then our results would lead one to conclude that the wrongful conviction rate for murder is roughly equal across races. As can be seen in Figure 2b, the shaded area reveals that only if one believes that the likelihood of DNA exoneration is more than 1.25 times higher among innocent black convicts than innocent white convicts convicted in the same year and same state would one conclude that that wrongful conviction rate for murder is higher among whites than blacks. However, we discuss in the next section why these results for murder may be less conclusive than even this would suggest.

Table 2 presents a series of robustness checks. In particular, it shows the estimated β coefficients under a variety of different assumptions regarding specification and sample selections.[7] For the estimates discussed above, we constrained the coefficient on the natural log of number of convictions to be one for both crimes, as implied by equation (2). These estimated β coefficients for rape and murder that were discussed above are shown again in the top row of Table 2. However, we can loosen this restriction and allow the coefficient on the natural log of convictions to differ from one. The second row of Table 2 shows that doing so does not appreciably impact our estimated β coefficients for either rape or murder. [8] The third and fourth rows show what happens to our estimated β coefficients if we use a Poisson specification rather than negative binomial, both with the coefficient on the natural log of convictions constrained to equal one and without this restriction. As can be seen, altering the specification in this way has minimal impact on the estimated β coefficients (or standard errors). Hence, the IRRs (and confidence intervals) associated with the implied β_1 coefficients corresponding to each assumed value for β_2 will be effectively the same as those shown in Figures 2a and 2b.[9]

Rows 5 through 11 of Table 2 show what happens when we make alterations to the sample used in each analysis.[10] Rows 5 and 6 show the results when we employ data from the same group of states in examining both types of crimes. Specifically, row 5 shows what happens to the β coefficients when we

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[7] Standard errors clustered at the state level are used in all specifications other than 8 and 9 where the number of clusters is too small.

[8] Coefficients on ln(convictions) in rape and murder specifications are positive but only marginally statistically different than zero (p-values of 0.10 in both cases).

[9] A Zero-inflated negative binomial specification would not be appropriate here, as such a specification presumes there may be additional causes for the outcome variable to equal zero than simple variation in the count around the expectation in any given observation. In other words, there may be additional predictors of whether the outcome variable is zero that are not related to the expected count process. That does not seem appropriate here, as the zeros seem to arise simply because the expected number of exonerations in any given year in any given state for either race is quite few.

[10] In each case we use the unconstrained negative binomial specification, as this specification leads to smaller standard errors and a higher log-likelihood. Results are essentially similar using the other specifications laid out at in rows 1-4.

expand the group of states used for each crime type to include all states with any DNA exonerations for rape *or* murder among the conviction cohorts examined, while row 6 shows what happens when we collapse the group of states used to analyze each crime type to include only states with DNA exonerations for both rape *and* murder among the conviction cohorts examined. Row 7 shows what happens when we exclude from the analysis states in which we interpolated conviction data for the crime in question for more than 2 years for each crime. As can be seen, none of these alterations to the group of states analyzed make any qualitative changes to the β coefficients.

Rows 8 and 9 show what happens to the β coefficients when we separate southern states from non-southern states. As can be seen, our results are statistically almost identical in southern states versus non-southern states. This finding is interesting in light of the fact that Alesina and La Ferrara's (2014) findings of racial differences in successful appeals of death penalties were primarily driven by southern states. It is not obvious why our results differ from Alesina and La Ferrara's (2014) in this dimension. Presumably part of the reason is that they only look at capital murder cases, where we include all rape and murder cases.

Rows 10 and 11 show what happens to the β coefficients when we look at pre-1988 conviction cohorts separately from post-1988 conviction cohorts. The reason we do this separation is that the first time DNA evidence was used to obtain an exoneration in a criminal proceeding in the United States was November 1987 (with the first time it was used to obtain an exoneration occurring in 1989). Hence, procedures for collecting and storing DNA evidence for crimes occurring prior to 1988 were likely to have been far more informal and less rigorous than for crimes occurring 1988 and later. As can be seen though, the same basic results hold for both those convicted pre-1998 and those convicted 1988 and after. While the β coefficient in the rape specification is larger for the 1988 and after conviction cohorts than the pre-1988 cohorts, this difference is not statistically significant.

Finally, row 12 of Table 2 shows what happens if we use all exonerations, not just DNA exonerations. As can be seen, the basic findings again remain the same. The coefficient on the black dummy variable from estimating equation (2) is positive and strongly statistically significant when it comes to rape, but much smaller in magnitude and not statistically different from zero when it comes to murder.

VI – Discussion

The primary message from the above results is that for one to not conclude that the wrongful conviction rate for rape is substantially higher among black citizens than white citizens, one would have to believe the DNA exoneration process is exceedingly biased in favor of innocent black defendants relative to innocent white defendants. By contrast, in order to conclude there does exist significant racial differences in the wrongful conviction for murder, one would have to believe the DNA exoneration process very strongly favors innocent convicts of one race over the other. So, the remaining question of interest is whether beliefs that the DNA exoneration is very strongly racially biased can be justified?

Regretfully, we have little direct evidence on the relative rates of DNA exoneration among innocent black convicts relative to innocent white convicts, and indeed we do not see how one could obtain direct evidence on this matter. However, we can rule out some potential mechanisms that could indirectly lead to innocent members of one race to be more likely to be exonerated by DNA evidence than members of another. For example, as technology has improved, more marginal DNA samples may be used to obtain exculpatory DNA evidence, meaning innocent individuals among more recent conviction cohorts may be more likely to be exonerated by DNA evidence than innocent individuals in more senior conviction cohorts. However, it is unlikely this explains our differing results across races for rape, as even if wrongful conviction rates within race have had different trends across conviction cohorts that interact with these changes in technology, we include conviction cohort fixed-effects in our regression specifications which should mitigate any bias associated with time trends.

Similarly, the DNA exoneration process certainly differs across states. So, one might be concerned that our results only reflect what is going on in the states where DNA exonerations are easier to obtain, and this is somehow correlated with the racial composition of the wrongfully convicted defendant pool, which could also lead to an indirect racial bias in the overall DNA exoneration process. Again, however, in all of our specifications we control for state fixed-effects, which should mitigate any such bias.

Another indirect way the DNA exoneration process might “favor” innocent black convicts over innocent white convicts is that innocent black convicts might receive longer sentences than innocent white convicts, and given that the DNA exoneration process takes many years, it may be that innocent white convicts are more likely to be released before the DNA exoneration process can play out, leading to a lower likelihood of DNA exoneration for innocent white convicts than innocent black convicts. However, as can be seen in Figures 3a and 3b, the sentencing distributions for rape and murder in the NCRP data actually appear to be quite similar across races.[11] For rape, the distribution for both blacks and whites is bimodal, with one mode around 60 months, and the other at 600 months (which is our top-code and includes all sentences in excess of 600 months including life sentences). While for murder, the vast majority of defendants of both races get a sentence in excess of 600 months (which again includes all life/death sentences). Notably however, these distributions are obviously for all of those convicted for murder and rape, not just the wrongfully convicted. Whether there exists large racial sentencing discrepancies among the wrongfully convicted, we just don’t know.

Another mechanism that could lead to a racial bias in the DNA exoneration process is that advocacy groups for the wrongfully convicted might focus their efforts on members of one race over another. While this is difficult to rule out on the whole given the wide variety of organizations involved in such efforts, when we discussed these issues with Justin Brooks, Director of the California Innocence Project, he said “(t)here is no reason for me not to believe the likelihood of exoneration for innocent whites is the same as it is for innocent blacks. Our process of case review is color blind, and habeas is as well. There are no juries involved, and it is mostly a paper process.” He also concurred that in DNA exoneration cases, the primary constraint is the existence of testable exculpatory DNA, which he also

[11] In doing this analysis, we did not include cases where the charge was “attempted.” We also top-coded sentences at 50 years (600 months), as well as coded life sentences and death sentences to be 50 years. It may be surprising that sentence length distributions are so similar across races. However, note that these sentences are being conditioned on type of crime (both of a very serious nature).

thought very unlikely to be correlated with the race of the defendant. However, it is possible other wrongful conviction advocacy groups have different philosophies.

While it is hard to directly evaluate whether advocacy groups on the whole focus their attention explicitly or implicitly on defendants of one race relative to another, we argue that we can at least get some indirectly evidence regarding this issue by looking at the time to exoneration among the DNA exonerees. In particular, if advocacy groups or judges consciously or unconsciously show more favor toward black defendants than white defendants, then one would suspect that innocent black convicts would on average be exonerated more quickly than innocent white convicts. To illustrate this, consider the analogy of an urn with red balls and blue balls, where the stock of balls in the urn represents all of those convicted for a given crime, and the red balls represent the wrongfully convicted. One would expect that the number of rounds it takes to discover each red ball would be decreasing in the number of draws each round.

If one considers a greater willingness of advocacy groups to take on cases with black defendants, or a greater willingness of judges to hear appeal cases with black defendants, to be analogous to more draws from the "black defendant" urn than the "white defendant" urn per year, then we should see a shorter mean time to exoneration among black exonerees than white exonerees. A similar analogy could be made if one suspects that there are more "obvious" miscarriages of justice amongst the wrongfully convicted who are black than among those who are white, and it is easier to get one's case examined if the case is more obviously flawed. While this could lead to a racial bias in favor of black defendants in the DNA exoneration process, it would again seem to imply that, on average, time to exoneration would be shorter among the exonerated black defendants than the exonerated white defendants. This is not what we observe however. Unconditionally, for both rape and murder, the time between conviction and DNA exoneration is roughly two years *longer* among exonerated black defendants than exonerated white defendants.

We look at this more formally in Table 3, which shows the results of several OLS regression specifications. The unit of observation is each individual exonerated by DNA evidence among those convicted between 1983 and 1998, and we regress time from conviction to exoneration on an indicator for whether the individual is black, along with controls for conviction year and region. As can be seen in specification (ii) for each crime, where conviction year is simply entered linearly, the negative coefficient on conviction year in each column suggests the time to exoneration becomes shorter and shorter the more recent the conviction (as should be expected as this technology improved over time). This appears to account for most of the longer time to exoneration among black defendants relative to white defendants convicted for rape, though not for murder. As shown in specification (iii) for each crime, there is no substantive difference if we control for conviction year via conviction year fixed-effects rather than a linear trend. In general, the results shown in Table 3 provide no evidence that time to exoneration is shorter for black exonerees than white exonerees, and in this way also do not provide evidence to suggest that the DNA exoneration process somehow strongly favors innocent black defendants over innocent white defendants. If anything, these results are somewhat suggestive of a racial bias against black defendants wrongfully convicted for murder.

Finally, we must consider what might explain why our results differ so dramatically across crime types. One plausible explanation is that the racial difference in wrongful conviction rates is simply much larger for rape than murder. Why might this be? One candidate is the use of witness identification evidence. One of the most notable differences between DNA exonerations for rape versus those for murder is that witness identification played a role in conviction for the vast majority of wrongful rape convictions for both races (83 percent of blacks, 72 percent of whites), but played a role in conviction for less than 25 percent of wrongful murder convictions for both races. This is of particular importance as a recent National Academy of Sciences panel was convened to assess the credibility of eyewitness identification in criminal cases (National Research Council 2014). As the report makes clear, while eyewitness identification tends to be a very credible form of evidence in the eyes of juries, ample evidence suggests it is highly prone to error. Moreover, cross-racial eyewitness identification is particularly prone to error (Meissner and Brigham 2001), with some evidence suggesting that this is particularly notable when the eyewitness is white and the accused is black (Brigham et al. 2007).[12]

On the other hand, there is a second possible explanation for why our results differ across crime types, which relates to a type of measurement error. Specifically, as alluded to previously, among those wrongfully convicted for murder, the likelihood of a DNA exoneration may be much higher if the murder included rape than if it did not. Indeed, about 60 percent of DNA exonerations for murder were cases in which there was also rape (National Registry of Exonerations 2015). However, the best available evidence we have seen suggests that rape is charged along with murder in only a tiny fraction of all murder arrests.[13] This issue might then lead to an implicit racial bias in the DNA exoneration process if the fraction of those wrongfully convicted for murder who were convicted for a rape/murder differs across races, as this would mean that the likelihood of a DNA exoneration among all of those convicted for murder would differ across races.

Controlling for this issue is simply not possible. The NCRP data we use to measure the number of convictions by race for each state and year only contains information on the most serious conviction charge. We also looked at data coming from the State Court Processing Statistics (US Department of Justice), which aims to collect data on a representative sample of those arrested for felonies in the largest 75 counties in the month of May in the United States over the period 1990-2009. While this dataset contains information on up to two different offense charges at the time of arrest, among the 1,273 defendants charged with murder, only 8 defendants were also charged with rape (of which 4 were black). We don't think this is enough data to make any inferences. Moreover, what we want to know is how this fraction differs by race among those *wrongfully convicted* for murder, which is not something we will

[12] One constraint of our approach is that because our unit of observation is an aggregate state/conviction year/race measure, we cannot control for individual case characteristics such as the race of the victim (nor do we have this data for a majority of our observations).

[13] The only data we know of that reports more than the most severe conviction charge for a large geographically diverse set of defendants is the State Court Processing Statistics (US Department of Justice 2014), which contains most serious conviction charge, but also up to three charged offenses. Less than one percent of those initially charged with murder were also initially charged with rape.

ever be able to observe. In general, it is certainly possible that this issue leads to a substantial racial bias in the DNA exoneration process. Whether this bias is large enough such that our estimates would suggest a racial difference in wrongful conviction rates for murder, we just can't know.

VII - Conclusion

What can DNA exonerations tell us about racial differences in wrongful conviction rates? The answer to this question depends on the type of crime. When it comes to rape, we think the answer is quite a lot. In particular, over a large range of assumptions regarding possible explicit or implicit racial biases in the DNA exoneration process, the data suggests the wrongful conviction rate for rape is significantly higher among black convicts than white convicts. In particular, if one believes that the likelihood of exoneration among innocent defendants convicted in the same year in the same state is roughly similar across races, then our results suggest that the wrongful conviction rate for rape is over two and a half times higher among black convicts than white convicts. By contrast, only if one believes that the likelihood of a DNA exoneration among innocent black defendants convicted for rape is over fifty percent higher than it is among innocent white defendants convicted for rape in the same state in the same year, would our results lead one conclude there is no racial difference in wrongful conviction rates for rape.

We think such a large bias in favor of black defendants in the DNA exoneration process when it comes to rape cases is unlikely given: (i) the primary hurdle to overcome in trying to obtain a DNA exoneration in a rape case is whether material containing this DNA was stored over time, which seems unlikely to be correlated with the race of the wrongfully convicted in rape cases (particularly for pre-1989 cases), and (ii) the time from conviction to exoneration among rape exonerees is quite similar across races, which would seem unlikely if advocacy groups or judges were very strongly biased in favor of black defendants.

Our results for murder are less conclusive. If one believes that the likelihood of exoneration among innocent defendants convicted in the same year in the same state is roughly similar across races, then our results suggest that the wrongful conviction rate for murder is statistically similar across races.

However, the fact that different types of murders may have very different likelihoods of potentially exculpatory DNA existing at the crime scene, and we know little about the distribution of different types of murders for which the wrongfully convicted were convicted for, much less how this distribution differs by race, it certainly seems possible that such issues could lead to substantial racial differences in the likelihood of DNA exoneration among those wrongfully convicted for murder. This issue is particularly notable given our finding that the time to exoneration is significantly longer among black DNA exonerees than white DNA exonerees. Therefore, we feel far less certain in claiming that our results imply that the wrongful conviction rate for murder is roughly equal across races. Rather, we think our methodology highlights the difficulties in making claims about racial differences in wrongful conviction rates for murder based on DNA exonerations.

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Fig. 1: DNA Exonerations by Conviction Year Cohort

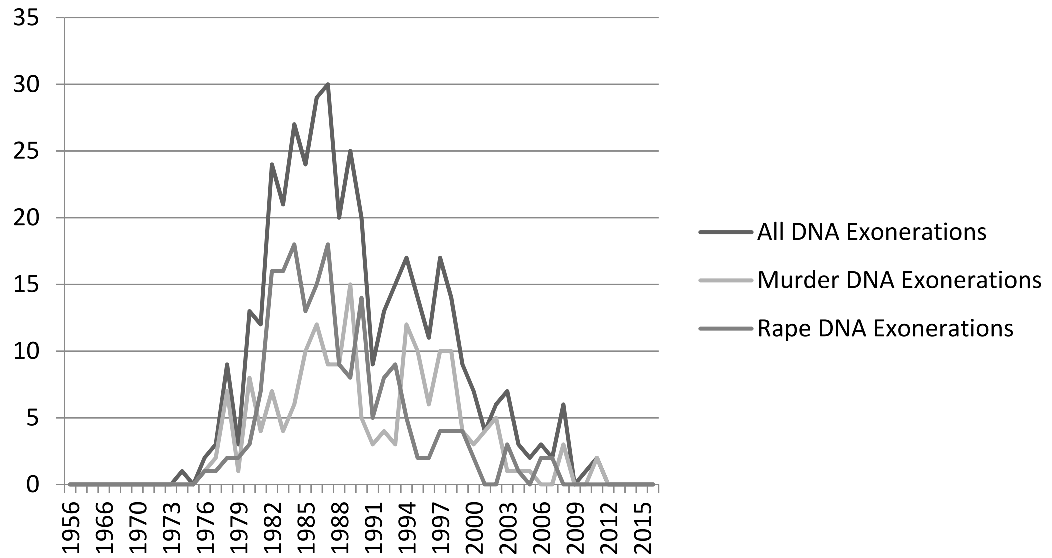
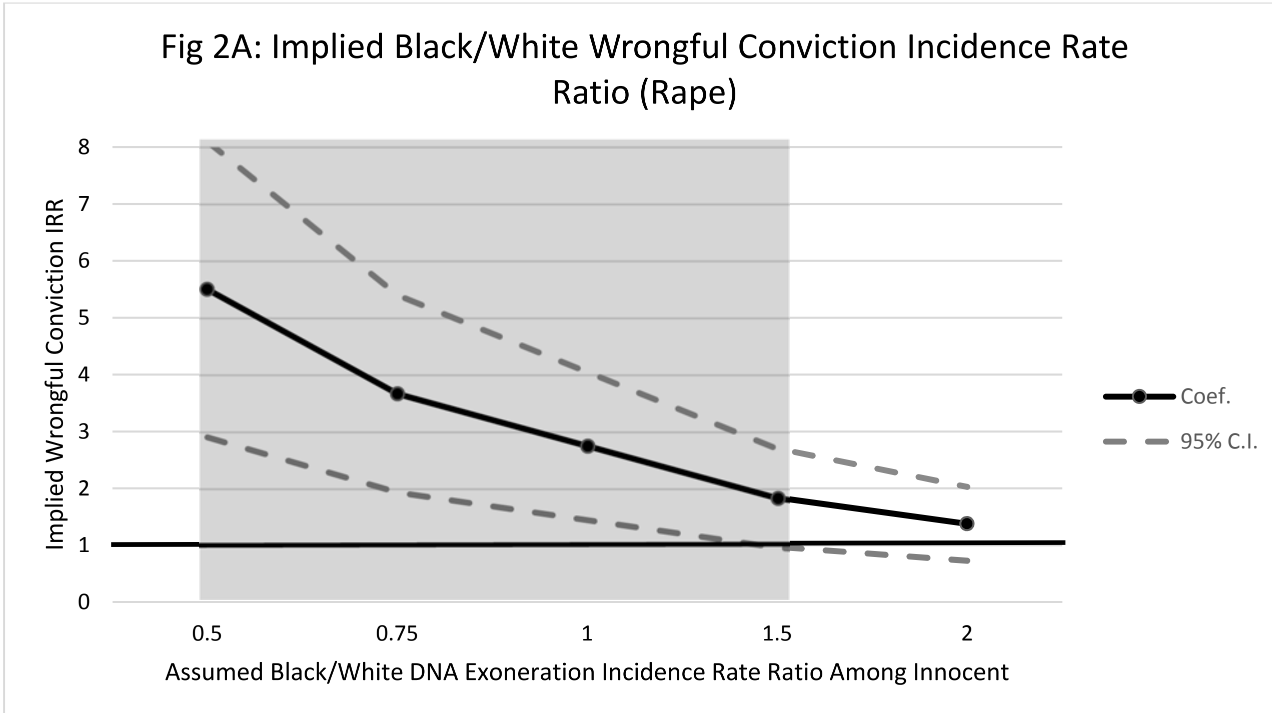
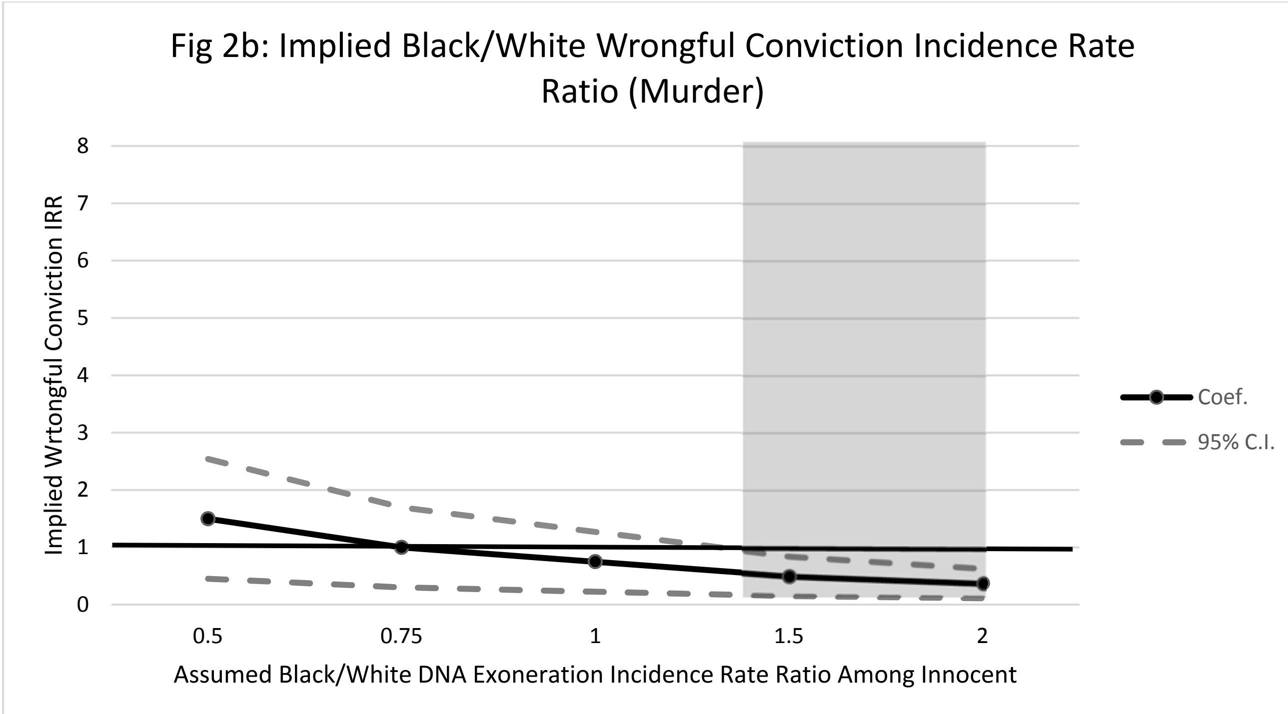


Table 1 - Description of Data Used for Analysis

	Rape				Murder			
			Number of yrs				Number of yrs	
State	Years		Conviction Data Interpolated	DNA Exonerations	Years		Conviction Data Interpolated	DNA Exonerations
AL	1983	1997	0	3				
CA	1983	1997	0	3	1983	1997	0	7
CO					1993	1996	0	1
FL	1989	1997	0	2	1985	1997	2	3
GA	1983	1996	1	5				
IL	1983	1986	0	10	1983	1997	0	17
KY	1988	1997	0	1				
MD	1983	1997	0	2	1983	1997	0	4
MA	1984	1995	1	5				
MI	1986	1997	5	1	1983	1997	1	1
MN	1985	1996	0	1				
MS	1983	1997	0	1	1983	1997	5	2
MO	1984	1984	0	4	1983	1993	6	1
NJ	1985	1996	0	4	1984	1997	0	3
NY	1984	1997	0	13	1984	1997	0	14
NC	1983	1997	0	4	1983	1997	2	5
OH	1984	1997	0	5	1984	1997	0	1
OK	1985	1996	0	2	1988	1996	0	5
PA	1984	1997	0	4	1984	1997	0	6
SC	1984	1997	0	1				
TN					1983	1997	0	2
TX	1983	1992	1	26	1983	1997	2	7
VA	1985	1997	0	4	1986	1997	0	1
WA	1986	1997	0	3				
WI	1983	1997	0	4	1988	1997	0	3



Incidence rate ratios along horizontal axis correspond to different β_2 parameters in equation (2). For example, a black/white DNA Exoneration Incidence Rate Ratio of 1 corresponds to $\beta_2 = 0$, while a black/white DNA Exoneration Incidence Rate Ratio of 1.5 corresponds to $\beta_2 = 0.4$. The dots on the graph then correspond to the black/white wrongful conviction incidence rate ratio that correspond to the β_1 implied by our estimated β and the assumed β_2. So, for example, given one assumes a black/white DNA Exoneration Incidence Rate Ratio of 1.5, one is implicitly assuming $\beta_2 = 0.4$. Therefore, given an estimated $\beta = 1.01$, this implies $\beta_1 = 1.01 - 0.4 = 0.61$, which in turn implies a black/white wrongful conviction incidence rate ratio of 1.84 as shown in the graph above. The dashed lines indicate the 95% confidence interval for the Incidence Rate Ratios, meaning the shaded area highlights the range of assumptions concerning black/white DNA Exoneration Incidence Rate Ratio over which the black/white wrongful conviction incidence rate ratio statistically differs from one at the 5% level.



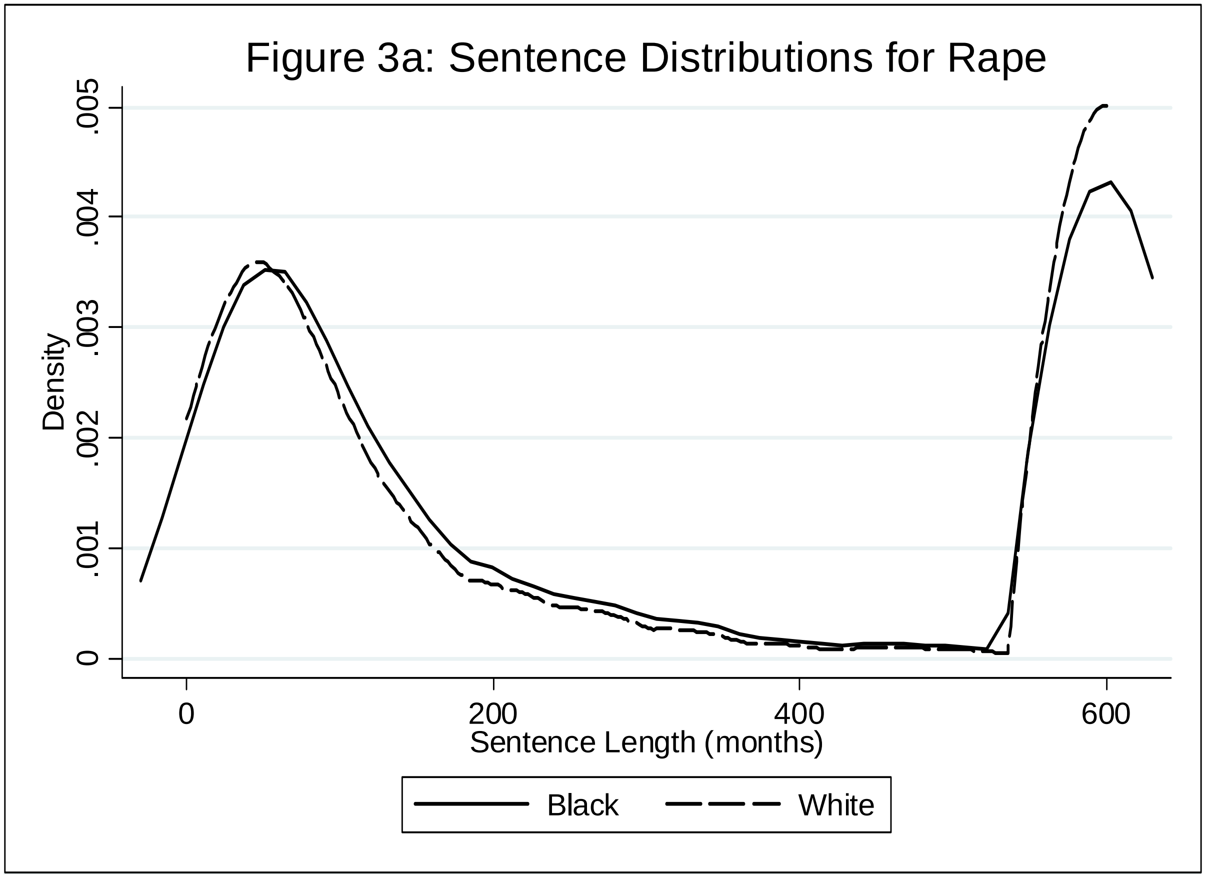
Incidence rate ratios along horizontal axis correspond to different β_2 parameters in equation (2). For example, a black/white DNA Exoneration Incidence Rate Ratio of 1 corresponds to $\beta_2 = 0$, while a black/white DNA Exoneration Incidence Rate Ratio of 1.5 corresponds to $\beta_2 = 0.4$. The dots on the graph then correspond to the black/white wrongful conviction incidence rate ratio that correspond to the β_1 implied by our estimated β and the assumed β_2. So, for example, given one assumes a black/white DNA Exoneration Incidence Rate Ratio of 1.5, one is implicitly assuming $\beta_2 = 0.4$. Therefore, given an estimated $\beta = -0.29$, this implies $\beta_1 = -0.29 - 0.22 = -0.69$, which in turn implies a black/white wrongful conviction incidence rate ratio of 0.50 as shown in the graph above. The dashed lines indicate the 95% confidence interval for the Incidence Rate Ratios, meaning the shaded area highlights the range of assumptions concerning black/white DNA Exoneration Incidence Rate Ratio over which the black/white wrongful conviction incidence rate ratio statistically differs from one at the 5% level.

Table 2 - Robustness Checks

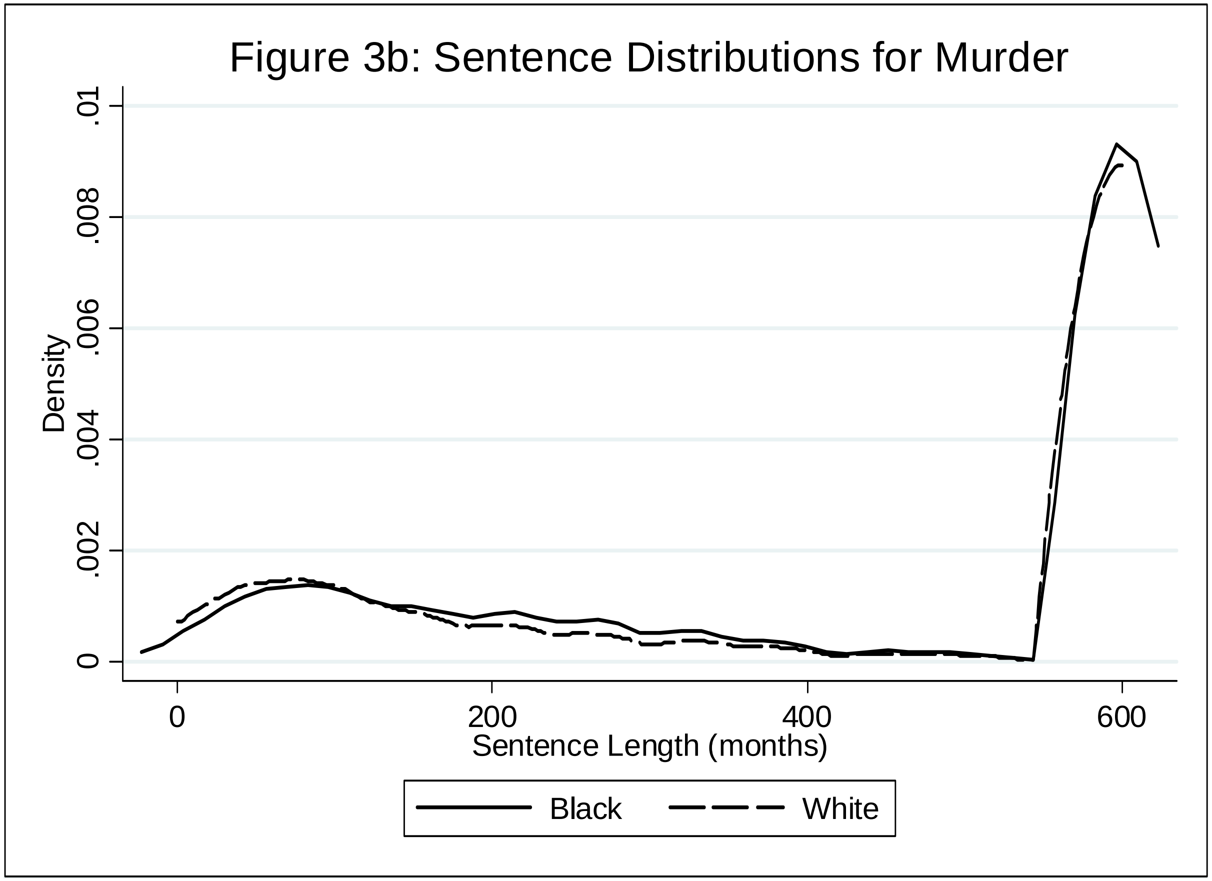
Specification	Data	β Coefficient Rape	β Coefficient Murder
1 - Base Specification - Negative Binomial with coefficient on ln(conviction) set equal to one.	Base Dataset (see Table 1)	1.01*** (0.24)	-0.29 (0.36)
2 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Base Dataset (see Table 1)	0.91*** (0.22)	-0.16 (0.24)
3 - Poisson with coefficient on ln(Convictions) set equal to one.	Base Dataset (see Table 1)	1.02*** (0.24)	-0.28 (0.37)
4 - Poisson with coefficient on ln(Convictions) unconstrained.	Base Dataset (see Table 1)	0.91*** (0.22)	-0.18 (0.24)
5 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	States with DNA exonerations for rape or murder (i.e., same state/yrs for both crime types)	0.96*** (0.23)	0.04 (0.28)
6 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	States with DNA exonerations for both rape and murder (i.e., same state/yrs for both crime types)	1.08*** (0.19)	-0.15 (0.25)
7 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Excluding states with interpolated conviction data for more than 2 years for that crime	0.97*** (0.24)	-0.07 (0.28)
8 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Southern States Only	1.03*** (0.34)	-0.15 (0.38)
9 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Non-Southern States Only	1.12*** (0.38)	0.14 (0.33)

10 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Conviction Cohorts 1983-1987 Only	0.96*** (0.41)	0.16 (0.43)
11 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Conviction Cohorts 1988-1997 Only	1.52*** (0.57)	0.01 (0.48)
12 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	All Exonerations (not just DNA) with Base Dataset	0.85*** (0.22)	-0.05 (0.21)

Reported βs correspond to the coefficients on the Black dummy variable in equation (2) in the text. Standard errors in parentheses. Standard errors are clustered by state in all specifications excluding 8 and 9. *** indicates significantly different from zero at 1% level. Estimated βs in all murder specifications are not statistically different from zero at even 10% level.



Data from National Convictions Reporting Data 1983-1997. Sentences topcoded at 600 months. Plot above comes from a kernel density estimate using an epanechnikov kernel with bandwidth of 30.



Data from National Convictions Reporting Data 1983-1997. Sentences topcoded at 600 months. Plot above comes from a kernel density estimate using an epanechnikov kernel with bandwidth of 23.

Table 3 - OLS Analysis of Time (Yrs) to Exoneration Among Exonerees

	Specification					
	Rape			Murder		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)
Black	1.92*	1.40	0.59	2.26***	2.42***	2.10***
	(1.12)	(1.01)	(1.05)	(.68)	(.65)	(.66)
Conviction Year		-0.79***			-0.52***	
		(.13)			(.08)	
Region South		1.95	1.41		-1.57*	-1.26
		(1.22)	(1.28)		(.84)	(.86)
Region West		2.1	1.26		-2.34**	-1.90*
		(2.06)	(2.14)		(1.09)	(1.12)
Region Midwest		0.01	-0.1		-0.42	-0.25
		(1.42)	(1.49)		(.86)	(.86)
Conviction Year Fixed-Effects	no	no	yes	no	no	yes

Standard errors in parentheses. *** indicates significantly different from zero at 1% level. ** indicates significantly different from zero at 5% level. * indicates significantly different from zero at 10% level.