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ABSTRACT

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

We examine the extent to which DNA exonerations can reveal whether wrongful conviction rates differ across races. We show that under a wide-range of assumptions regarding possible explicit or implicit racial biases in the DNA exoneration process (including no bias), our results suggest the wrongful conviction rate for rape is substantially and significantly higher among black convicts than white convicts. By contrast, we show that only if one believes that the DNA exoneration process very strongly favors innocent members of one race over the other could one conclude that there exist significant racial differences in wrongful conviction rates for murder.

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I - Introduction

  This paper attempts to evaluate whether wrongful conviction rates for rape and murder differ across races. On the face of it, this seems like a very difficult task as it is simply not possible to know innocence or guilt with certainty for a large 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.

  Given this, we attempt to determine what can be learned about overall racial differences in wrongful conviction rates from DNA exonerations. We show that standard regression methods 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 DNA exoneration among innocent convicts. We then show that it is possible to back out the parameter of interest---namely the parameter that captures the difference in wrongful conviction rates by race---if one is willing to make an assumption regarding the extent to which the likelihood of DNA exoneration among the innocent does or does not differ by race. While we have little evidence to suggest the likelihood of DNA exoneration actually differs across innocent individuals by race, we also cannot definitively rule out the possibility it does. Therefore, our methodology is to consider a variety of assumptions regarding racial bias in the DNA exoneration process and see how that impacts our conclusions regarding racial differences in wrongful conviction rates.

  If one believes that the likelihood of DNA exoneration among innocent convicts convicted in the same year in the same state is roughly similar across races, then our results suggest the wrongful conviction rate for rape among black convicts is over *two and a half times* higher than it is among white convicts. This racial disparity in wrongful conviction rates for rape must be even wider if one believes innocent black convicts are less likely than innocent whites to be exonerated by DNA evidence, and moreover, our results continue to suggest that the wrongful conviction rate for rape is significantly higher among black convicts than white convicts even if one believes the likelihood of DNA exoneration is seventy-five percent more likely for innocent blacks than innocent whites.

By contrast, if we again start with the assumption that the likelihood of DNA exoneration among innocent convicts convicted in the same year in the same state is similar across races, our results do not provide any evidence to suggest significant racial difference in wrongful conviction rates for murder. We show that only if one believes that innocent black convicts are over fifty percent more likely to be exonerated by DNA evidence than their white counterparts could one conclude that the wrongful conviction rate for murder is significantly higher among whites than blacks. Analogously however, if one has the opposite beliefs, namely that innocent black convicts are little less than half as likely to be exonerated by DNA evidence as their white counterparts, then our results suggest the wrongful conviction rate for murder is significantly higher among black convicts than white convicts.

As a whole, we think this paper provides relatively strong evidence that the wrongful conviction rate for rape is substantially higher among black convicts than white convicts, and this racial discrepancy in wrongful conviction rates is substantially larger for rape than murder. We think this to be the most plausible interpretation of our results; for one to conclude otherwise, one would have to believe that the likelihood of obtaining a DNA exoneration is on average at least twice as high for innocent black defendants convicted for rape than innocent whites convicted for rape in the same state and year. We find such beliefs somewhat untenable for a few reasons. First, in order for a wrongly convicted individual to obtain a DNA exoneration there must exist exculpable DNA evidence at the crime scene and this material must have been properly collected stored over a relatively long time frame, both of which seem unlikely to be strongly correlated with the race of the wrongly convicted individual. Second, among DNA exonereees, the time from conviction to exoneration are very similar across races (or even slightly longer for black exonerees than white exonerees), which would also seem to be unlikely if the DNA exoneration process so strongly favors innocent black defendants over innocent white defendants. Finally, if one believes that advocacy groups target their efforts so strongly in favor of black defendants over white defendants that this explains our results with respect to rape (despite the similar times to exoneration), then one would still have to account for why this strong favoritism only arises in rape cases and not in murder cases.

On the other hand, for the reasons discussed above, we think it quite plausible that the likelihood of a DNA exoneration is roughly similar between innocent black and white defendants convicted in the same year in the same state for the same crime type, which would lead to the conclusion that the wrongful conviction rate among black convicts is well over twice as high as it among white convicts convicted for rape, but roughly equal across races when it comes to murder. As to why such a large racial discrepancy in wrongful conviction rates might arise with respect to rape but not murder, we think a possible explanation relates to the fact that eyewitness testimony is far more frequently cited as key evidence among those convicted but later exonerated for rape than murder. Given that research has shown eyewitness testimony is highly prone to error, particularly when the assailant is black (National Academy of Sciences 2014), this is a mechanism that can plausibly explain why there would be a much larger racial difference in wrongful convictions for rape than murder.

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

There exists a long list of writings documenting wrongful convictions in the U.S. (Borchard 1932; Brandon and Davies 1973; Huff and Rattner 1988; Protess and Warden 1998; Christianson 2004; 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.

Wrongful convictions 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 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 are similarly averse to convicting innocent defendants of all races, but 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.

To date, most studies on racial disparities in the judicial system have focused on policing and sentencing.[1] The handful of studies looking at racial discrepancies in wrongful convictions have either focused on specific case studies (Parker et al 2001), or simply looked at the racial composition of a collection of exonerated defendants (Bedau and Radelet 1987; Huff et al. 1996; Radelet et al. 1996; Harmon 2001; Gross and O'Brien 2008).

The exceptions are Harmon (2004) and Alesina and La Ferrara (2014), who extend this literature by focusing on all 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

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[1] Studies looking at racial bias in policing include Anwar and Fang (2006), Antonovics and Knight (2009), Knowles Persico and Todd (2001), Grogger and Ridgeway (2006), and Gelman, Fagan, and Kiss (2007). Studies looking at racial bias in sentencing include Bushway and Piehl (2001), Ulmer, Light, and Kramer (2011), and Rehavi and Starr (2014). These are just a few examples.

white defendants. Alesina and La Ferrara (2014) argue that this provides evidence of racial bias with respect to death penalty cases.

Our analysis is complementary to the work by Alesina and La Ferrara (2014) in that it is examining a similar topic, but it differs in its approach in some important ways. Specifically, while Alesina and La Ferrara's (2014) approach is confined to death penalty convictions, we consider all murder and rape convictions. 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. As we discuss below, we think our approach is the first that specifically tests for differences in racial differences in *wrongful conviction raters* for all rape and murder convictions over a relatively long stretch of time.

DNA Exonerations

DNA evidence was first used to 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, the vast majority of innocent defendants who have been exonerated via DNA evidence received legal assistance from groups such as the various Innocence Projects or law school clinics. The cases these organizations take-up generally 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, exclusionary DNA evidence simply doesn't exist. As stated by Barry Scheck and Peter Neufeld, the co-founders of the Innocence Project,

> "(t)he practical roadblock faced by inmates seeking to prove their innocence (via DNA evidence) is finding the evidence. In 75 percent of the Innocence Project cases, matters in which it has been established that a favorable DNA result would be sufficient to vacate the inmate's conviction, the relevant biological evidence has either been destroyed or lost" (Scheck and Neufeld 2001, pp. 245).

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 and was collected at the crime scene, and whether such evidence was effectively stored---that arguably seem unlikely to be related to the characteristics to the wrongfully convicted individual in question, particularly for those convicted prior to 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 all defendants convicted for a given crime who are actually innocent of that crime. 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 fraction 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

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

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 a reasonable starting place is to assume $\beta_2 = 0$, 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 key 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.

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 DOJ 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). 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 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 90th 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.[2]

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 well as any states with less than 15,000 black residents according to the 1990 census, and any state/years where there were fewer than ten black individuals convicted for the crime in question. We also have to deal with the fact that NCRP convictions data is not reported in some states in some years. To deal with these missing observations 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.[3]

Table 1 shows which state/years are included in our rape and murder analyses respectively, as well as the fraction 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

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

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.

As discussed earlier, the issue to overcome is that estimating the parameters of equation (2) only gives us an estimate of β, which equals $(\beta_1 + \beta_2)$, while our parameter of interest is just β_1. Therefore, to obtain estimates of β_1 for each type of crime we must make an assumption regarding the size of β_2. Our

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

[3] 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.

starting point is to assume that the probability of being exonerated by DNA evidence among innocent defendants does not differ by race after controlling for state and conviction year fixed-effects, which would imply $\beta_2 = 0$. Given our discussion of the DNA exoneration process in Section II, we think this is a reasonable assumption to start with. However, we also consider a variety of other assumptions regarding β_2 and see how these alter the conclusions about the size of β_1 given our estimates of β.

Our main results are shown in Table 2. The top row of numbers show results for rape. As can be seen in column (i), our estimated β equals 1.01, which is positive and statistically different than zero at well beyond the 1 percent level.[4] Column (ii) shows that when we assume the probability of DNA exoneration conditional on innocence does not systematically differ by race of defendant (i.e., assume $\beta_2 = 0$), the incidence rate ratio (IRR) associated with the implied β_1 of 1.01 equals 2.74, suggesting the wrongful conviction rate among blacks convicted for rape is well over two and a half times higher than it is among whites convicted for rape. Below the implied IRR we report the p-value from a Wald test of the null hypothesis that $\beta_1 = 0$ given the assumed value for β_2 in that column (i.e., we test whether the difference between our estimated β and our assumed value for β_2 differs significantly from zero). As can be seen, if we assume $\beta_2 = 0$, we can strongly reject the null that $\beta_1 = 0$ (p-value < 0.001).

The second row of numbers in columns (i) and (ii) of Table 2 show analogous results for murder. As can be seen, the estimated β is negative in sign but not even close to statistically different from zero at even the 10 percent level. Looking at the second row of column (ii) we see that under the assumption that the probability of DNA exoneration conditional on innocence does not systematically differ by race (i.e., assuming $\beta_2 = 0$), the incidence rate ratio associated with the implied β_1 equals 0.76. While this might suggest the wrongful conviction rate for murder is slightly lower among black convicts than white convicts, we cannot reject the null hypothesis that wrongful conviction rates for murder are equal across races at any standard level of statistical significance (p-value = 0.45).

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[4] State and conviction year fixed-effects are included in all regressions. Standard errors clustered by state for all estimates. Standard errors are marginally smaller without clustering.

Column (iii) of Table 2 shows that if we assume innocent black defendants are twenty-five percent more likely to be exonerated by DNA evidence than innocent whites (equivalent to assuming $\beta_2 = 0.22$), then given our estimate of β, the incidence rate ratio associated with the implied β_1 would still lead us to conclude that black convicts are well over twice as likely to be wrongfully convicted for rape than white convicts, and still strongly reject the null hypothesis that $\beta_1 = 0$ (p-value = 0.001). However, even under this assumed bias in the DNA exoneration process in favor of innocent black convicts, we still cannot reject the null hypothesis that black and white convicts are equally likely to be wrongfully convicted for murder at even the ten percent level.

Moving out to column (v) of Table 2, we can see that even if we assume innocent black convicts are seventy-five percent more likely to be exonerated by DNA evidence than innocent white convicts, our results would still suggest that black convicts are about fifty percent more likely to be wrongfully convicted for rape than white convicts, and can still reject the null hypothesis that wrongful conviction rates for rape are equal across races at the ten percent level (p-value = 0.06). However, as the second row of column (v) shows, when we assume that innocent black convicts are over seventy-five percent more likely to be exonerated by DNA evidence than innocent white convicts, our results would now suggest that black convicts are only about half as likely as white convicts to be wrongfully convicted for murder, and we would be able to reject the null hypothesis that the wrongful conviction rate for murder is equal across races at the two percent level.

It is important to note, however, that in Table 2 we don't show the IRRs for the implied β_1's associated with assumed values of β_2 less than zero. In other words, we don't show what the implied racial differences in wrongful conviction rates would be if we were to assume that innocent black convicts were *less* likely to be exonerated by DNA evidence than innocent white convicts. However, it is quite straightforward to describe what would arise under such assumptions. Namely, if one were to assume the DNA process was biased against innocent black convicts and in favor of innocent white convicts, our results would suggest wrongful conviction rates for rape would be three or more times higher among black convicts than white convicts. Moreover, if one were to assume innocent blacks convicted for

murder were forty-percent as likely to be exonerated by DNA evidence as innocent whites convicted for murder (i.e., assume $\beta_2 = -0.88$), our results would suggest the wrongful conviction rate for murder would be significantly higher among black convicts than white convicts at the ten percent level.

Table 3 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. For the estimates shown in Table 2, we constrained the coefficient on the natural log of number of conviction to be one for both crimes, as implied by equation (2). These are shown again in the top row of Table 3. However, we can loosen this restriction and allow the coefficient on natural log of convictions to differ from one. The second row of Table 3 shows that doing so does not appreciably impact our estimated β coefficients for either rape or murder. [5] 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 natural log of convictions constrained to equal one and without this restriction. As can be seen, altering the specification in this way has very little impact on the estimated β coefficients (or standard errors). Hence, the IRRs associated with the implied β_1 coefficients corresponding to each assumed value for β_2 (and associated p-values for null hypothesis test) will be effectively the same as those shown in Table 2.

Rows 5 through 11 of Table 3 show what happens when we make alterations to the sample used in each analysis.[6] 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 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

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[5] 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).

[6] 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.

more than 15 percent of the 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 is interesting in light of the fact that Alesina and La Ferrara's (2014) findings that show black defendants who received the death penalty upon being convicted for killing a white victim were more likely to have their case overturned on statutory appeal than white defendants who received the death penalty for being convicted for killing a white victim, 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, but this is an issue that might be a good avenue for further research.

Finally, rows 10 and 11 show what happens to the β coefficients when we look at pre-1988 conviction cohorts separately from conviction cohorts from 1988 and after. The reason we do this separation is because the first time DNA evidence was used 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.

As a final note regarding Table 3, when it comes to murder, the estimated β coefficient across specifications and sub-samples are generally much closer to zero than in specification 1, which corresponds to what was shown and evaluated in Table 2. Hence, these alternative specifications provide even less evidence for a large racial difference in wrongful conviction rates for murder than shown in Table 2.

VI – Discussion

As discussed above, how one interprets our results depends on what one believes about any explicit or implicit racial biases in the DNA exoneration process. On the one hand, if one believes that the likelihood of a DNA exoneration among innocent defendants is roughly the same by race among those convicted in the same state in the same year, then our results suggest black citizens are far more likely to be wrongfully convicted for rape than white citizens, but wrongful conviction rates for murder are roughly equal across races. Alternatively, if one believes that the DNA exoneration process very strongly favors innocent white defendants over innocent black defendants, then our results would suggest the wrongful conviction rate is higher for black citizens than white citizens for both rape and murder. By contrast, if one believes that the DNA exoneration process somehow very strongly favors innocent black defendants over innocent white defendants, one would conclude that the wrongful conviction rate for murder is somewhat lower among black citizens than white citizens, but one would still generally conclude that the wrongful conviction rate for rape is significantly higher among black citizens than white citizens.

While the results as described above certainly reveal that our approach leaves some ambiguity with respect to our question of interest, we think the strongest take-away message 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 (on the order of innocent black defendants being twice as likely to obtain a DNA exoneration relative to innocent white defendants). So, one remaining question is whether there is any evidence to suggest such beliefs are 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, as discussed in Section II, the basic process seems to involve several components that seem unlikely to have any correlation with the race or a wrongfully convicted defendants (e.g., whether there was exculpable DNA evidence at the crime scene and whether

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this evidence was saved properly), and the legal groups involved in these cases say they do not focus their efforts on members of one race relative to another. Indeed, 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 thought very unlikely to be correlated with race of defendant.

We can also rule out some potential mechanisms that could indirectly lead to innocent members of one race being 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 likely 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. This

does not seem likely though, as the NCRP data reveal that among the conviction cohorts studied here, the 25th, 50th, and 75th percentiles of the sentence length distribution are the same for black and white defendants convicted for rape (96 months, 240 months, and life/death respectively). [7] Similarly, the 25th, 50th, and 75th percentiles of the sentence length distribution are almost the same for black and white defendants convicted for murder (25th percentile 360 months for whites and 336 months for blacks, 50th and 75th percentiles are life/death sentences for both blacks and whites). So, as the above distributions of sentence lengths make clear, among those incarcerated for both rape or murder, the sentences are very similar across races and generally long enough among convicted defendants of both races for the DNA exoneration process to play out (as stated previously, the average length to exoneration among our DNA exonerees is 14 years or 168 months).

Thinking further about the length of time it takes to obtain a DNA exoneration among exonerees gives us a potentially more direct test of whether there exists a large racial bias in the DNA exoneration process. 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 defendants would on average be acquitted more quickly than innocent white defendants. 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. Clearly, 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 the mean time to exoneration be shorter among black exonerees than white exonerees. This is not what we

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[7] In doing this analysis, we topcoded 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 implicitly being conditioned on type of crime (both of a very serious nature), as well as being conditioned on the defendant being sentenced to incarceration.

observe however. Overall, 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. Looking at this issue more formally, Table 4 shows the results of several OLS regression specifications, where the unit of observation is individuals exonerated by DNA evidence, and we regress time 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 suggest 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, nothing really changes if we control for conviction year via conviction year fixed-effects rather than a linear trend. In general though, the results shown in Table 4 provide no evidence that time to exoneration is shorter for black exonerees than white exonerees, and in this way also do not provide any evidence to suggest that the DNA exoneration process somehow strongly favors innocent black defendants over innocent white defendants.

Finally, we must consider what might explain why our results differ so dramatically across crime types. If one thinks that a bias in the DNA exoneration process in favor of black defendants accounts for our results with respect to rape, then one must consider why this bias in the DNA exoneration process does not appear to arise with respect to murder. By contrast, examination of our exoneration data suggests a plausible explanation for why a racial difference in wrongful conviction rates might be much larger for rape than murder. Namely, 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).[8]

VII - Conclusion

This paper provides some of the first statistical evidence directly analyzing racial differences in wrongful conviction rates. Our results reveal that if one believes the likelihood of DNA exoneration among the innocent is roughly similar across races, then the wrongful conviction rate for rape is over two and a half times higher among black convicts than white convicts, but the wrongful conviction rate for murder is roughly equal across races. For one to conclude that the wrongful conviction rate among black individuals convicted for rape is not significantly higher than it is among white individuals convicted for rape, one must believe that innocent black defendants are more than twice as likely to be exonerated by DNA evidence as innocent white defendants convicted in the same state in the same year for the same crime. Furthermore, for one to believe that such a large racial bias in the DNA exoneration process explains our results with respect to rape, then one must also either conclude that the wrongful conviction rate for murder is much lower among black defendants than white defendants, or that the racial bias in the DNA exoneration process only applies to rape cases and not murder cases. On the other hand, if one believes that the DNA exoneration process generally strongly favors innocent white convicts over innocent black convicts, then our results would lead one to conclude that the wrongful conviction rate is higher among black defendants than white defendants for both rape and murder, but this difference is vastly larger with respect to rape.

In the end, we think the totality of the evidence presented here suggests that among those convicted for rape, the wrongful conviction rate is substantially higher among black defendants than

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

white defendants, as the assumptions required to conclude otherwise seem hard to reconcile with both

stated practices by advocates for the wrongfully convicted and observed evidence regarding time to

exoneration across races. Moreover, we posit that there exists a credible mechanism for why racial

differences in wrongful conviction rates might be large for rape cases but not necessarily for murder---

namely the greater prevalence of eyewitness evidence in rape cases than murder cases. While such

evidence often seems quite convincing to juries, it has been shown to have high rates of error, particularly

when it comes to black suspects. In this way, we think this work further emphasizes the need to reform

the way witness identification is handled by police and courts and adopt the "best practices"

recommended by the recent National Academy of Sciences report (National Research Council 2014).

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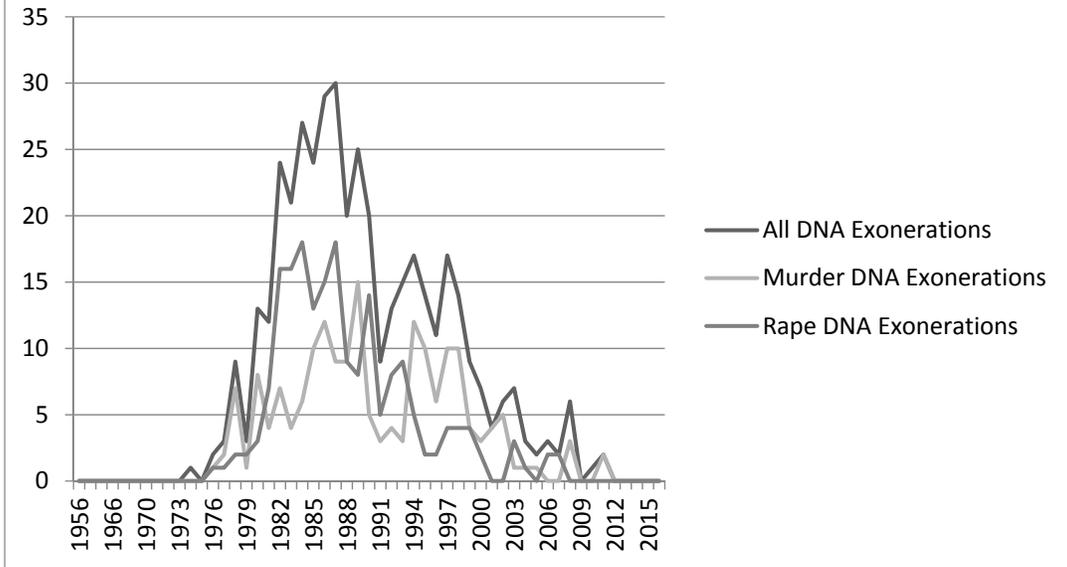
Fig. 1: DNA Exonerations by Conviction Year Cohort

Table 1 - Description of Data Used for Analysis

State	Years		Rape Fraction of Conviction Yrs Interpolated	DNA Exonerations	Years		Murder Fraction of Conviction Yrs Interpolated	DNA Exonerations
AL	1983	1997	0.00	3				
CA	1983	1997	0.00	3	1983	1997	0.00	7
CO					1993	1996	0.00	1
FL	1989	1997	0.00	2	1985	1997	0.15	3
GA	1983	1996	0.08	5				
IL	1983	1986	0.00	10	1983	1997	0.00	17
KY	1988	1997	0.00	1				
MD	1983	1997	0.00	2	1983	1997	0.00	4
MA	1984	1995	0.13	5				
MI	1986	1997	0.42	1	1983	1997	0.07	1
MN	1985	1996	0.00	1				
MS	1983	1997	0.00	1	1983	1997	0.33	2
MO	1984	1984	0.00	4	1983	1993	0.65	1
NJ	1985	1996	0.00	4	1984	1997	0.00	3
NY	1984	1997	0.00	13	1984	1997	0.00	14
NC	1983	1997	0.00	4	1983	1997	0.13	5
OH	1984	1997	0.00	5	1984	1997	0.00	1
OK	1985	1996	0.00	2	1988	1996	0.00	5
PA	1984	1997	0.00	4	1984	1997	0.00	6
SC	1984	1997	0.00	1				
TN					1983	1997	0.00	2
TX	1983	1992	0.11	26	1983	1997	0.13	7
VA	1985	1997	0.00	4	1986	1997	0.00	1
WA	1986	1997	0.00	3				
WI	1983	1997	0.00	4	1988	1997	0.00	3

Table 2 - Estimates of Racial Difference in Wrongful Conviction Rates by Crime Type

		Incidence Rate Ratios (IRR) Associated with "Black" Under Different Assumptions Regarding β_2			
	(i)	**(ii)**	**(iii)**	**(iv)**	**(v)**
		$\dfrac{\Pr(exon|I,\ black)}{\Pr(exon|I,\ white)} = 1$	$\dfrac{\Pr(exon|I,\ black)}{\Pr(exon|I,\ white)} = 1.25$	$\dfrac{\Pr(exon|I,\ black)}{\Pr(exon|I,\ white)} = 1.50$	$\dfrac{\Pr(exon|I,\ black)}{\Pr(exon|I,\ white)} = 1.75$
Crime Type	Coefficient on Black Indicator	$\beta_2 = 0$	$\beta_2 = 0.22$	$\beta_2 = 0.40$	$\beta_2 = 0.56$
rape	$\beta = 1.01$	IRR[β_1] = 2.74	IRR[β_1] = 2.20	IRR[β_1] = 1.84	IRR[β_1] = 1.57
	s.e. = 0.24	pval (H$_0$: β_1= 0)= 0.000	pval (H$_0$: β_1= 0)= 0.001	pval (H$_0$: β_1= 0)= 0.011	pval (H$_0$: β_1= 0)= 0.06
murder	$\beta = -0.29$	IRR[β_1]= 0.75	IRR[β_1] = 0.60	IRR[β_1] = 0.50	IRR[β_1] = 0.43
	s.e. = 0.36	pval (H$_0$: β_1= 0)= 0.45	pval (H$_0$: β_1= 0)= 0.15	pval (H$_0$: β_1= 0)= 0.05	pval (H$_0$: β_1= 0)= 0.02

Notes: Pr(*exon|I, black*) refers to the probability of DNA exoneration conditional on innocence and being black (analogous for "white"). See equation (2) and associated text for discussion of what β, β_1, and β_2 refer to. IRR stands for "Incidence Rate Ratio" associated with the implied β_1 coefficient. Regression specifications also include state and year fixed-effects and the natural log of Convictions for each state/year/race (with coefficient constrained to equal one). Standard errors clustered by state

Table 3 - Robustness Checks

Specification	Data	β Coefficient	
		Rape	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 both 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 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 15% of years for that crime	1.02*** (0.31)	-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*** (0.31)	0.16 (0.43)
11 - Negative Binomial with coefficient on ln(Convictions) unconstrained.	Conviction Cohorts 1988-1997 Only	1.52*** (0.51)	-0.01 (0.32)

Standard errors in parentheses. Standard errors are clustered by state in 1-5. *** indicates significantly different from zero at 1% level.

Table 4 - 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.