



Racial Disparity in U.S. Imprisonment Across States and Over Time

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Abstract

Objectives We analyze the contribution of changes in the black–white racial disparity in imprisonment to changes in the black incarceration rate. We also describe the behavior of the racial disparity across states and across time.

Methods We use state level incarceration data for non-Hispanic black and white males to perform a decomposition of the black incarceration rate. This allows us to attribute changes in black incarceration to changes in the racial disparity and changes in the overall incarceration rate. We use a Fourier approximation to identify structural change points for the racial disparity at both the state and national level.

Results The large increase in black imprisonment between 1978 and 1999 was driven by increases in the overall rate of imprisonment, while the smaller decrease which occurred between 1999 and 2014 was driven by reductions in the black–white racial disparity. For many states, the racial disparity increased starting in the mid-1980s, where this increase may have been linked to the crack epidemic. Many states experienced a downturn in the racial disparity starting in the 1990s. Whatever its other effects, this suggests that the 1994 crime bill did not aggravate the preexisting racial disparity in imprisonment. California’s experience has been strongly counter to national trends with a large increase in the racial disparity beginning in the early 1990s and continuing until near the end of our sample.

Conclusion While the racial disparity in imprisonment has been falling since 1996, it remains quite high as of 2014. Future work is required to better understand the policy determinants of this disparity.

Keywords Incarceration · Racial disparity · 1994 crime bill

Introduction

The extraordinarily high rate of incarceration of Black Americans is a function of two factors. First, the United States has a very high overall incarceration rate. In 2014, this rate was 693 per 100,000 inhabitants, which was the second highest rate in the

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world.¹ Second, there are very large racial disparities in imprisonment rates in the United States. In 2014, non-Hispanic black males were incarcerated at 5.5 times the rate of non-Hispanic white males.² The high overall incarceration rate in the United States combined with the large racial disparity led to an incarceration rate of 2784 per 100,000 Black males in 2014.³ The primary focus of this paper is on this racial disparity. We provide a largely descriptive analysis of how this disparity varies across states and across time. It is notable that there is wide variation in the black–white imprisonment ratio across states. For example, in 2014 the black-to-white incarceration ratio ranged from 1.60 in Hawaii to 13.8 in Minnesota.

Between 1978 and 1999 there is an extraordinarily large increase in the national black incarceration rate as it rose from about 1080 to near 3500. We decompose this change at the state level in order to attribute the sources of the change at the national level. We find the increase in black incarceration is overwhelmingly due to increases in the overall incarceration rate in the U.S. during this period. Between 1999 and 2014 there is a moderate fall in the black incarceration rate to about 2800. Over 50% of this fall is due to a reduction in the black–white disparity during this period. There is already a large Black–White disparity in imprisonment at the beginning of our sample which is 1978.⁴ In many states, this disparity worsens beginning in the mid-1980s. This corresponds to the period of the crack epidemic. Evans et al. (2016) document an upsurge in incarceration of young black men during this period and attribute this directly to the crack epidemic. Many states experienced a downturn in the racial disparity beginning sometime in the 1990s. The timing of these downturns suggests that, whatever its other effects, the 1994 crime bill did not exacerbate the racial disparity in imprisonment. Several provisions of this bill, including incentives to build prisons, hire more police and for the adoption of truth-in-sentencing laws, had the potential for producing a racially disparate impact, but we find no *prima facie* evidence that this is the case. California is a notable exception to the national trend as it experienced a large rise in the racial disparity beginning in the early 1990s and continuing until near the end of our sample period.

Background

Incarceration rates rose sharply from the 1970s through the 1990s. One intuitive explanation for the spike in the incarceration rate is that this occurred in response to a spike in crime. As crime rates rise/fall we expect incarceration rates to rise/fall as well (perhaps with a lag). However, as shown in Fig. 1, the data do not show such a simple relationship between crime and incarceration rates. Incarceration rates followed the violent crime rate up from 1978 to the early 1990s. However, the substantial drop in the violent crime rate since the early 1990s has only been met with a flattening out of the incarceration rate.⁵ Thus, while the violent crime rate plays a role in determining the imprisonment rate, other factors are also clearly important.

¹ The Institute for Criminal Policy Research lists Seychelles as having a higher imprisonment rate than the United States. You can view their ranking at http://www.prisonstudies.org/highest-to-lowest/prison_population_rate?field_region_taxonomy_tid=All.

² Our analysis throughout focuses on the imprisonment rates of non-Hispanic black and white males at the state level.

³ All subsequent references to the incarceration rate, this should be understood as being per 100,000 population of the relevant group. The figures throughout include state prisoners only.

⁴ This is the earliest year in which we can get jurisdictional data on race.

⁵ Figure 1 shows the violent crime rate, but the story is similar if we graph the overall crime rate, the felony arrest rate or the overall arrest rate. Our figure begins in 1978 which is the starting point for our sample on incarceration. However the increase in violent crime rates dates to the 1960s.

Blumstein and Beck (1999) state that only 12% of the growth in the state prison population between 1980 and 1996 was due to increases in rates of offending. They attributed the remaining 88% to increases in the imposition of sanctions (51%) and longer sentences served (37%). While other articles in the literature echo this view (e.g., Zimring and Hawkins 1993), the literature finds the crime rate coefficient to be positive and significant when explaining prison populations or admissions (Michalowski and Pearson 1990; Arvanites 1992; Arvanites and Asher 1995, 1998; Beckett and Western 2001; Greenberg and West 2001; Jacobs and Helms 2001; Sorensen and Stemen 2002; Smith 2004). For example, Stemen et al. (2005) found that incarceration rates grew more in states with higher property crime rates than in other states. Some studies suggest that these coefficients could have been underestimated as they ignore the simultaneous relationship between prisons and crime (Listokin 2003).⁶

The political climate of the last few decades has led to much harsher sentencing policies. Those policies have been at the heart of the debate aimed at explaining the boom in incarceration rates in the United States. A series of laws were passed in the 80s and 90s which reflected the political imperative to get “tough on crime”. The 1984 Comprehensive Crime Control Act signed by President Ronald Reagan was the first major revision of the U.S. criminal code since the early 1900s. The Sentencing Reform Act, which was part of the 1984 Act, prescribed sentencing guidelines and eliminated judicial discretion in order to increase consistency in federal sentencing.

Soon after, the 1986 Anti-Drug Abuse Act established mandatory minimum sentences for federal drug offenses. This act is widely believed to have had a racially disparate impact that disfavored black Americans. The act sets a minimum sentence of 5 years without parole for possessing 5 g of crack cocaine (mostly used by blacks) while giving the same punishment for holding 500 g of powder cocaine (mostly used by whites).⁷ In the early 90s, a growing number of states started to pass three-strikes and truth-in sentencing laws which overall, resulted in longer prison sentences. This was followed in 1994 by President Clinton’s Crime Bill, the largest crime bill in the history of the United States.⁸ The bill promised \$10 billion to states for prison construction between 1995 and 2000, but only for states that passed truth-in-sentencing laws that eliminated most “good time” provisions and required convicted offenders to serve 85% of their prison sentence. The effect on state policy was almost immediate, the number of states with truth-in-sentencing statutes growing from 4 in 1992 to 27 in 1998. The bill also provided funds for the hiring of 100,000 additional police.⁹ These provisions of the bill could affect black incarceration either through the overall incarceration rate or through an effect on the racial disparity. Our analysis will focus on possible effects on the racial disparity. To the best of our knowledge this question has not been addressed in the prior literature.

⁶ Using the technique of Granger causality for almost 20 years of state-level data on incarceration and crime rate, Marvell and Moody (1995) found that a 10% increase in prison populations led to a 1.5% reduction in crime rates.

⁷ This despite the fact that crack cocaine and powdered cocaine are pharmacologically equivalent. The sentencing disparity is reduced, but not eliminated in 2010. Bjerk (2017) argues that court rulings in the mid-2000s, which made sentencing guidelines advisory and revisions to these guidelines in 2007 had a larger effect on reducing crack sentences than the 2010 act.

⁸ The 1994 Violent Crime Control and Law Enforcement Act.

⁹ There were many other provisions of the bill, but these provisions are unlikely to affect either the black incarceration rate or the racial disparity for prisoners held at the state level. Among other things, the bill provided for an expansion of the federal death penalty and the establishment of a federal three strikes provision. Neither of these provisions is likely to have a significant effect on state level incarceration data.

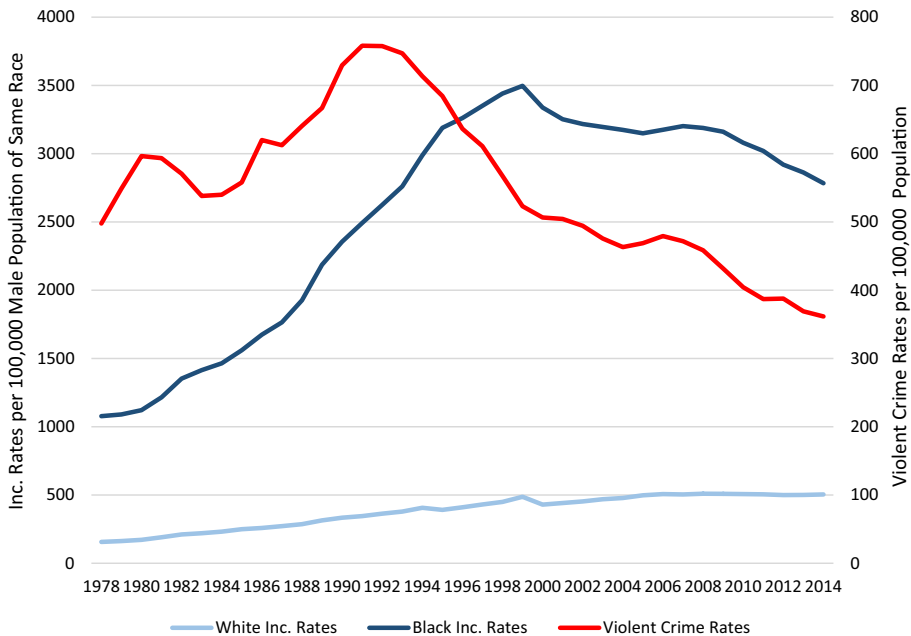


Fig. 1 U.S. Black male and white male incarceration rates and violent crime (incarceration rates are on the left scale and violent crime rates on the right scale). *Sources:* National Prisoner Statistics (NPS), compiled by the Bureau of Justice Statistics. FBI, Uniform Crime Reports, prepared by the National Archive of Criminal Justice Data

The key feature of the data is that the imprisonment rate has not followed the crime rate down. Pfaff (2017) argues that this is due to an increased probability of imprisonment, conditional upon arrest. He attributes this to changes in prosecutorial behavior at the county level. Pfaff (2017, 5–6) also argues that the war on drugs is not primarily responsible for mass incarceration as only about 16% of state prisoners are incarcerated for drug offenses.¹⁰

We turn next to analyses of the racial disparity in imprisonment. Blumstein (1982) concluded that racial patterns of arrests explained about 80% of the disparities in imprisonment. His conclusions were confirmed by Langan (1985) who used victim data instead of arrest and prison admission data instead of population data.¹¹ More recent studies (Tonry and Melewski 2008; Baumer 2013), using the same method as Blumstein, found that racial disparities in imprisonment became much worse in the twenty-first century and that between 39 and 66% of racial disparities could not be explained by arrest patterns. However, Beck and Blumstein (2017) argue that a higher percentage of the racial disparity can be attributed to differential rates of offending, if Hispanic arrestees are properly taken into account. On average, they find that 72% of the disparity in imprisonment can be explained by differential rates of offending, but this varies widely by the type of crime. Moreover, this

¹⁰ This argument runs counter to Alexander (2010).

¹¹ Crutchfield et al. (1994) argue that aggregate results conceal considerable heterogeneity across jurisdictions. For example, the percentage of the black-white imprisonment disparity which can be explained by arrests varies considerably across states.

still suggests a substantial portion of the disparity in imprisonment cannot be explained by differential rates of offending.¹²

Papers in the line of Blumstein (1982) use arrest or victimization data in order gain insight into how much of the racial disparity in imprisonment can be explained by differential rates of offending. Typically the focus is on a single year or on a handful of years' worth of data. By contrast, we make no attempt to analyze how much of the racial disparity can be explained by differential rates of offending. Rather we analyze the behavior of the racial disparity over a long time period across all fifty states. The perspective we gain from such an analysis provides clues as to the role of events such as the crack epidemic or laws, such as the crime bill of 1994 on the racial disparity. We also perform a decomposition which gives us insight into how changes in the racial disparity and the overall level of imprisonment have each affected the black imprisonment rate over time.

An important predecessor to our work is Bridges and Crutchfield (1988). They regressed both black imprisonment rates and white imprisonment rates on state characteristics, and then tested the statistical differences between those two models. They also regressed the black-to-white imprisonment rates ratio on those same state characteristics. Overall, social characteristics of states were found to contribute significantly to racial disparity in imprisonment. Racial disparities are found to be positively associated with the degree of urban concentration of blacks and to a lesser extent the black to white economic inequality ratio.¹³ However, they find state legal characteristics to have little to no effect on imprisonment rates and racial disparity in imprisonment. It is worth noting that we use the same measure of racial disparity as Bridges and Crutchfield, by taking the ratio of the black to white imprisonment rate. Our work contrasts with theirs by analyzing the behavior of the racial disparity over time rather than focusing on the cross sectional determinants of the disparity.

Bridges and Crutchfield provide a regional analysis of the racial disparity. Another important work along these lines is by Muller (2012). He argues that the origin of the racial disparity in northern states was a reaction by recent European immigrants to the influx of blacks from the south. His statistical analysis of census data from the period 1880–1950 shows that greater black migration into a state leads to a higher black incarceration rate within that same state. Muller's work is notable because, as we shall see, northern and Midwestern states tend to have a very large racial disparity in imprisonment. The dynamics described by Muller for this earlier period are likely important in explaining the initial racial disparity we observe at the beginning of our data set in 1978. As in Muller and Bridges and Crutchfield, our work provides an extensive regional analysis of the racial disparity.

Our purpose in this paper is two-fold. First, we want to describe the sources of the vast increase in black imprisonment since the late 1970s. How much of this is due to the overall increase in imprisonment in the United States and how much is due to changes in the racial disparity in imprisonment? We do this by decomposing changes in the black imprisonment

¹² Another recent contribution is by Kim and Kiesel (2017). They use New York data and while they find some heterogeneity across the state they find that the racial disparity in prison sentencing is largely explained by the racial disparity in arrests. Thus, the racial disparity in imprisonment is largely explained by factors occurring at the arrest stage or earlier in the process.

¹³ The result on inequality is consistent with the theoretical model developed by Curry and Klumpp (2009).

rate at the state level and then aggregate up to the national level. Second, we want to shed light on the question of whether one particular piece of legislation, the 1994 crime bill, aggravated the preexisting racial disparity in imprisonment. We do this by estimating when local maxima and minima occur in the black–white disparity at the state level in the years before and after this crime bill is passed.

Data

We use two different datasets to construct our two main variables: incarceration rates by state and their corresponding black-to-white ratios. We obtained state-level prison populations from 1978 to 2014 using the National Prisoner Statistics (NPS) dataset compiled by the Bureau of Justice Statistics. The NPS breaks down the number of prisoners under the jurisdiction of each state by sex and race. Jurisdictional data on race only goes back to 1978, which is why this is the first year in our dataset. In our analysis, we only focus on non-Hispanic white and black males.¹⁴ We extracted state-population estimates broken down by sex and race from the U.S. Census Bureau. Because those estimates are created using censuses conducted every 10 years and some variables/definitions changed over time, we made a few changes to maintain consistency. First, prior to 1980, the Census did not differentiate Hispanics from non-Hispanics. In order to be consistent with the following years as well as with the prisoners' data (which separated Hispanics from non-Hispanics for the whole period), we estimated the years 1978–1980.¹⁵ We used the average growth of the population for each state in order to perform this estimation.

Second, in 2000, the Census started to allow individuals to self-identify with more than one race. This led to the creation of a new variable (two or more races) which impacted all the other variables. To deal with this new variable, the census made available two different datasets: one that excluded all those identified as two or more races from the other races, and the other that included them (hence, allowing for individuals to be accounted two times or more). For example, an individual who identifies as both white and Asian would be accounted for only once under the two or more races variable in the first dataset, and would be accounted for once under the white variable, and once under the Asian variable in the second dataset.¹⁶ This change thus led to discrepancies between data prior to 2000 and post-2000, whichever post-2000 dataset we used. We decided to use the growth rates of the raw data to estimate all the values after 1999 in order to get a more continuous variable. Specifically, we used the average percent yearly change during each 5-year period (i.e. 2000–2004, 2005–2009, and 2010–2014) in the raw data combined with the previous value (starting with 1999) to estimate all the values after 1999. For example, any 2000

¹⁴ A few missing variables were estimated by taking the mean of the adjacent observations. We do not use federal prisoner data due to major changes in reporting by race and Hispanic origin, which begin in 2011. Because of these changes, the federal time series is not comparable to the time series produced by the state level data. As noted by Pfaff (2017), among others, the vast majority (approximately 87%) of prisoners are held at the state level.

¹⁵ Data on the Hispanic population from 1980 was only available at the National-level, so the state-level population needed to be estimated. The census provides state level estimates on the Hispanic population 1981–2014.

¹⁶ Prior to 2000, this person would have been accounted for only once under either white or Asian.

value would be equal to its corresponding 1999 value times one plus its 2000–2004 corresponding growth rate.¹⁷

Using these two datasets, we calculated the incarceration rate per 100,000 male inhabitants for both blacks and whites, where these rates are denoted by B and W respectively. We also calculated the overall incarceration rate, denoted A , which corresponds to the sum of the black plus white prisoners per 100,000 of the black plus white population. Figure 1 shows the black and white imprisonment rates over time. The black imprisonment rate rises sharply between 1978 and 1999 and then falls slowly between 1999 and 2014. As a result of this pattern, we will focus some of our analysis on the years 1978, 1999 and 2014. Part of our goal is to understand the sharp rise and smaller subsequent decrease in the black imprisonment rate in terms of overall incarceration in the United States and the racial disparity between blacks and whites. Table 1 shows the black imprisonment rate across states for the years 1978, 1999, and 2014. The cross state variation is very large. For example, in 2014, this rate (per 100,000) ranges from about 900 in Hawaii to about 5500 in Wisconsin and Vermont. The rate aggregated over all 50 states (but excluding federal prisoners) rises from 1080 in 1978 to about 3500 in 1999. This rate subsequently falls to 2784 by 2014.

Our measure of the racial disparity, $r=B/W$, is shown in Table 2.¹⁸ Nationally, there is a large initial racial disparity equal to 6.9 in 1978 and this rises slightly to 7.1 in 1999. This rate then has a fairly substantial decrease to 5.5 in 2014. What the national figures do not show is the high variability in this ratio across states. For example, in 2014, the racial disparity ranged from 1.6 in Hawaii to 13.8 in Minnesota. States with the highest black-to-white ratio are disproportionately located in the Northeast and Midwest. In 2014, the states with the ten highest racial disparities were all in the Northeast or Midwest. On the other hand, states with the lowest black-to-white ratio are overwhelmingly from the South, with some from the West. In 2014, 9 of the 10 states with the lowest racial disparity were in the South or West. These results are largely in line with the prior analysis of Bridges and Crutchfield (1988, Table 1).

Decomposition of the Changes in Black Imprisonment Over Time

As noted earlier, the national black-male-incarceration rate rose from about 1080 in 1978 to a peak of about 3500 in 1999. It then declined to 2784 in 2014. In this section, we decompose the sharp upward movement in this rate between 1978 and 1999 and the smaller decrease observed between 1999 and 2014. Our goal is to understand how changes in the racial disparity and the overall incarceration rate contributed to the rise in black imprisonment. To perform this decomposition, we cannot simply rely on the national data. For example, if the overall incarceration rate were to rise in a state with a large black population, this would increase the black–white ratio at the national level even if this ratio is unchanged in the state in question. To avoid this type of aggregation issue, we first

¹⁷ If g is the growth rate of, say, the black alone population over 2000–2004, then our estimate of the black population in 2000 is $(1+g) \times$ black population in 1999 and our 2001 estimate is $(1+g)^2 \times$ black population in 1999 and so on.

¹⁸ This racial disparity is reported in Beck and Blumstein (2017), except that they allocated Hispanics to the black and white categories. One result of this is that their reported ratios are generally somewhat smaller than ours. Their Table 4 reports this ratio for 1990 and 2011 for the 10 states with the highest ratio and the 10 states with the lowest ratio.

decompose the incarceration rates at the state level and then aggregate up to the national level. Our decomposition will allow us to state how, for example, the changing racial disparity in Florida contributed to the national rise in black incarceration in the 1978–1999 period. To do this we first need to determine how the changes in each state’s black incarceration rate contributed to the national rate. We will then decompose changes in the state black incarceration rate into changes in the racial disparity, the overall incarceration rate and demographics within that state.¹⁹

Consider first how state incarceration rates aggregate to form the national rate. Let S_i^t be state i ’s share of the national black population in year t , and let B_i^t be that state’s black incarceration rate in year t . The national black incarceration rate in year t is B_N^t . We then have the following:

$$B_N^t = \sum_{i=1}^{50} S_i^t B_i^t. \tag{1}$$

We can compute the contribution of changes in state i ’s black incarceration rate to the change in the national rate between 1999 and 1978 by using the difference $B_i^{1999} - B_i^{1978}$. This change can be weighted by either S_i^{1999} or S_i^{1978} . We do this both ways and then take the average contribution to determine how changes in the state’s black incarceration rate contributed to changes in the national rate. Let $B_{Ni}^{1999-1978}$ be the contribution of the change in the black incarceration rate in state i to the change in the national black incarceration rate between 1999 and 1978. We then have

$$B_{Ni}^{1999-1978} = (0.5)(B_i^{1999} - B_i^{1978})(S_i^{1999} + S_i^{1978}) \tag{2}$$

We can express $B_{Ni}^{2014-1999}$ by a suitable adjustment of the time superscripts in Eq. (2).

By making an analogous computation, we can compute the contribution of changes in the demographic weights S to the change in the black national imprisonment rate. For example, we have $S_{Ni}^{1999-1978} = (0.5)(S_i^{1999} - S_i^{1978})(B_i^{1999} + B_i^{1978})$. Combined with (2), this yields the full decomposition of the national black incarceration rate as follows:

$$B_N^{1999} - B_N^{1978} = 0.5 \sum_{i=1}^{50} [(B_i^{1999} - B_i^{1978})(S_i^{1999} + S_i^{1978}) + (S_i^{1999} - S_i^{1978})(B_i^{1999} + B_i^{1978})]. \tag{3}$$

Equation (3) provides an exact decomposition of the change in the national rate into the changes in the state rates and the black population shares. In what follows we will focus on the changes in the state black incarceration rates as shown in Eq. (2).

Once we have the contribution of changes in the B_i to the change in the national black incarceration rate, the next step is to decompose the change in each state’s black incarceration rate into three component parts: changes in the state’s racial disparity $r=B/W$; changes in the overall incarceration rate in the state, A (including whites and blacks only); and changes in the demographic weights x , where x is the number of black men in state i divided by the total number of black and white men in state i . This will allow us to control for demographic effects on the black–white imprisonment ratio.

¹⁹ Muller (2012, 288–291) also performs a decomposition, but his emphasizes black migration across states and is concerned with the period 1880–1950.

Table 1 Black incarceration rates (BIR)—per 100,000 population

Region	State	1978 BIR	1978 rank	1999 BIR	1999 rank	2014 BIR	2014 rank
Midwest	Illinois	827	35	3211	28	3227	24
Midwest	Indiana	729	41	3340	26	3416	19
Midwest	Iowa	1779	4	5779	5	4735	4
Midwest	Kansas	1180	19	3875	16	3330	22
Midwest	Michigan	1481	10	3750	21	3489	15
Midwest	Minnesota	1294	16	2870	35	2824	30
Midwest	Missouri	1171	20	3845	18	3482	16
Midwest	Nebraska	1872	2	2864	36	3390	20
Midwest	North Dakota	242	47	1787	49	1243	49
Midwest	Ohio	1339	15	3805	19	3315	23
Midwest	South Dakota	800	37	2997	32	2437	35
Midwest	Wisconsin	1541	9	6724	1	5493	2
Northeast	Connecticut	1377	13	5989	2	4153	5
Northeast	Maine	436	45	1850	48	1993	46
Northeast	Massachusetts	982	29	1868	47	1386	48
Northeast	New Hampshire	282	46	2698	39	2069	43
Northeast	New Jersey	847	34	3751	20	2398	36
Northeast	New York	1012	27	3010	31	2000	45
Northeast	Pennsylvania	887	32	3711	22	3991	8
Northeast	Rhode Island	1067	25	4216	11	3819	9
Northeast	Vermont	178	48	4094	13	5526	1
South	Alabama	694	42	2904	34	2999	26
South	Arkansas	762	40	2940	33	3532	14
South	Delaware	1719	7	5867	3	4110	7
South	Florida	1726	6	3415	25	3467	17
South	Georgia	1011	28	2537	43	2349	38
South	Kentucky	769	39	3935	15	2909	27
South	Louisiana	884	33	3587	24	3728	10
South	Maryland	1365	14	2551	42	1864	47
South	Mississippi	458	44	2709	38	2372	37
South	North Carolina	1145	22	2391	45	2063	44
South	Oklahoma	1153	21	5333	6	5085	3
South	South Carolina	925	31	2659	41	2202	41
South	Tennessee	818	36	2713	37	2481	33
South	Texas	1260	17	5789	4	3650	12
South	Virginia	1021	26	2478	44	2844	29
South	West Virginia	584	43	2004	46	2455	34
West	Alaska	2330	1	3944	14	2742	31
West	Arizona	1847	3	4730	7	4148	6
West	California	790	38	4273	10	3382	21
West	Colorado	1070	24	4122	12	3430	18
West	Hawaii	124	49	1127	50	908	50
West	Idaho	1115	23	2690	40	3669	11
West	Montana	930	30	3135	29	2679	32

Table 1 (continued)

Region	State	1978 BIR	1978 rank	1999 BIR	1999 rank	2014 BIR	2014 rank
West	Nevada	1728	5	3861	17	3185	25
West	New Mexico	1439	11	3227	27	2218	40
West	Oregon	1260	18	3675	23	3631	13
West	Utah	1408	12	4640	8	2864	28
West	Washington	1582	8	3066	30	2258	39
West	Wyoming	0	50	4352	9	2102	42
	National ^a	1080	–	3500	–	2784	–

^aThe national figures aggregate over the 50 states, but do not include federal prisoners

Note that the overall incarceration rate in state i in year t is simply the weighted average of the black and white rates:

$$A_i^t = x_i^t B_i^t + (1 - x_i^t) W_i^t. \tag{4}$$

Substitute $W_i^t = B_i^t / r_i^t$ into (4) and solve for B_i^t to get the following:

$$B_i^t = \frac{r_i^t A_i^t}{r_i^t x_i^t + 1 - x_i^t} \tag{5}$$

Equation (5) expresses the black incarceration rate as a function of the overall incarceration rate A_i^t , the racial disparity r_i^t and demographic weights, x_i^t . We will use Eq. (5) to decompose the change in a state’s black incarceration rate into components which reflect changes in A , r , and x . Note, we are not implying a causal relationship via (5), as the black incarceration rate is simply a component of the overall rate. However, it is useful to decompose the black incarceration rate into overall incarceration trends and the racial disparity. If $r > 1$, which is generally true, then a rise in x , which is an increase in the black share of the black plus white male population, will lead to a decrease in B holding A and r constant. While we report the effects of changes in the x ’s on the tables which follow, this will not be a focus of our discussion.

There is not a unique way in which to perform this decomposition. If r , A and x are set at their 1978 values in (5) we can estimate the effect of changing r on B , by changing r to its 1999 value, while keeping A and x at their 1978 values. However, we can also compute the effect of changing r with either A or x at its 1999 value or with both A and x at their 1999 value. Since there are four ways to compute the effect of a change in r on B , we simply average across all four. We compute the contributions of changes in A and x in a completely analogous fashion. Let $A_{Bi}^{1999-1978}$, $r_{Bi}^{1999-1978}$ and $x_{Bi}^{1999-1978}$ be the respective contributions of the overall incarceration rate, the racial disparity and the demographic weights to the change in state i ’s black incarceration rate between 1999 and 1978. We then have the following:

Table 2 Black–White ratio

Region	State	B–W ratio	1978 rank	B–W ratio	1999 rank	B–W ratio	2014 rank
Midwest	Illinois	7.9	18	13.3	7	10.4	7
Midwest	Indiana	5.1	35	8.3	17	5.6	22
Midwest	Iowa	15.3	4	16.5	4	12.1	4
Midwest	Kansas	8.7	16	9.0	13	7.6	15
Midwest	Michigan	10.0	11	7.9	21	7.4	16
Midwest	Minnesota	17.3	1	24.1	1	13.8	1
Midwest	Missouri	8.8	15	6.6	32	4.8	31
Midwest	Nebraska	17.2	2	8.8	15	9.1	12
Midwest	North Dakota	4.9	37	7.8	22	3.9	45
Midwest	Ohio	10.2	10	8.6	16	6.4	19
Midwest	South Dakota	6.9	22	5.5	44	4.3	38
Midwest	Wisconsin	17.1	3	16.9	2	13.5	3
Northeast	Connecticut	9.1	13	16.9	3	10.2	8
Northeast	Maine	3.4	46	7.3	27	6.8	18
Northeast	Massachusetts	14.4	5	9.8	11	7.9	13
Northeast	New Hampshire	4.5	40	7.7	23	5.4	25
Northeast	New Jersey	10.9	9	13.9	6	13.7	2
Northeast	New York	7.1	19	9.9	10	9.5	10
Northeast	Pennsylvania	12.9	6	16.0	5	10.4	6
Northeast	Rhode Island	9.5	12	11.8	8	10.6	5
Northeast	Vermont	1.0	49	9.4	12	10.2	9
South	Alabama	4.6	39	5.7	40	3.9	43
South	Arkansas	5.7	31	6.1	35	4.2	40
South	Delaware	7.1	20	7.0	28	4.7	32
South	Florida	6.2	27	6.0	38	4.1	41
South	Georgia	4.3	41	5.0	46	3.9	44
South	Kentucky	5.4	34	7.9	20	3.8	46
South	Louisiana	6.4	26	6.8	31	4.5	36
South	Maryland	11.1	8	8.8	14	5.4	26
South	Mississippi	3.9	44	5.6	42	3.7	47
South	North Carolina	4.3	42	7.0	29	5.1	29
South	Oklahoma	5.7	32	6.3	33	5.1	28
South	South Carolina	3.1	47	5.6	41	5.0	30
South	Tennessee	5.1	36	6.2	34	4.3	39
South	Texas	4.3	43	3.7	47	4.6	35
South	Virginia	6.4	25	7.7	24	5.7	21
South	West Virginia	5.5	33	6.1	36	4.0	42
West	Alaska	8.5	17	5.5	43	3.2	49
West	Arizona	7.0	21	6.9	30	5.1	27
West	California	4.7	38	8.2	18	9.4	11
West	Colorado	6.7	23	6.0	37	7.2	17
West	Hawaii	2.7	48	2.3	50	1.6	50
West	Idaho	6.6	24	3.7	48	4.5	37
West	Montana	6.1	30	5.9	39	4.6	34

Table 2 (continued)

Region	State	B–W ratio	1978 rank	B–W ratio	1999 rank	B–W ratio	2014 rank
West	Nevada	6.2	28	5.3	45	4.6	33
West	New Mexico	3.6	45	3.4	49	5.8	20
West	Oregon	6.2	29	7.6	25	5.4	24
West	Utah	11.7	7	10.1	9	7.7	14
West	Washington	8.9	14	7.6	26	5.6	23
West	Wyoming	0.0	50	8.0	19	3.2	48
	National ^a	6.9	–	7.1	–	5.5	–

^aThe national figures aggregate over the 50 states, but do not reflect the racial disparity in federal imprisonment

$$\begin{aligned}
 r_{Bi}^{1999-1978} = & 0.25 \left(\frac{r^{1999}A^{1978}}{r^{1999}x^{1978} + 1 - x^{1978}} - \frac{r^{1978}A^{1978}}{r^{1978}x^{1978} + 1 - x^{1978}} \right. \\
 & + \frac{r^{1999}A^{1999}}{r^{1999}x^{1978} + 1 - x^{1978}} - \frac{r^{1978}A^{1999}}{r^{1978}x^{1978} + 1 - x^{1978}} \\
 & + \frac{r^{1999}A^{1978}}{r^{1999}x^{1999} + 1 - x^{1999}} - \frac{r^{1978}A^{1978}}{r^{1978}x^{1999} + 1 - x^{1999}} \\
 & \left. + \frac{r^{1999}A^{1999}}{r^{1999}x^{1999} + 1 - x^{1999}} - \frac{r^{1978}A^{1999}}{r^{1978}x^{1999} + 1 - x^{1999}} \right) \tag{6a}
 \end{aligned}$$

$$\begin{aligned}
 A_{Bi}^{1999-1978} = & 0.25 \left(\frac{r^{1978}A^{1999}}{r^{1978}x^{1978} + 1 - x^{1978}} - \frac{r^{1978}A^{1978}}{r^{1978}x^{1978} + 1 - x^{1978}} \right. \\
 & + \frac{r^{1999}A^{1999}}{r^{1999}x^{1978} + 1 - x^{1978}} - \frac{r^{1999}A^{1978}}{r^{1999}x^{1978} + 1 - x^{1978}} \\
 & + \frac{r^{1978}A^{1999}}{r^{1978}x^{1999} + 1 - x^{1999}} - \frac{r^{1978}A^{1978}}{r^{1978}x^{1999} + 1 - x^{1999}} \\
 & \left. + \frac{r^{1999}A^{1999}}{r^{1999}x^{1999} + 1 - x^{1999}} - \frac{r^{1999}A^{1978}}{r^{1999}x^{1999} + 1 - x^{1999}} \right) \tag{6b}
 \end{aligned}$$

$$\begin{aligned}
 x_{Bi}^{1999-1978} = & 0.25 \left(\frac{r^{1978}A^{1978}}{r^{1978}x^{1999} + 1 - x^{1999}} - \frac{r^{1978}A^{1978}}{r^{1978}x^{1978} + 1 - x^{1978}} \right. \\
 & + \frac{r^{1999}A^{1978}}{r^{1999}x^{1999} + 1 - x^{1999}} - \frac{r^{1999}A^{1978}}{r^{1999}x^{1978} + 1 - x^{1978}} \\
 & + \frac{r^{1978}A^{1999}}{r^{1978}x^{1999} + 1 - x^{1999}} - \frac{r^{1978}A^{1999}}{r^{1978}x^{1978} + 1 - x^{1978}} \\
 & \left. + \frac{r^{1999}A^{1999}}{r^{1999}x^{1999} + 1 - x^{1999}} - \frac{r^{1999}A^{1999}}{r^{1999}x^{1978} + 1 - x^{1978}} \right) \tag{6c}
 \end{aligned}$$

Note that $A_{Bi}^{2014-1999}$, $r_{Bi}^{2014-1999}$ and $x_{Bi}^{2014-1999}$ are defined and computed in an analogous manner. In (6a), where we are computing the effect of the change in r_i on B_i , each of the four lines in the parentheses has r^{1999} in the first term and r^{1978} in the second. The four lines show the four combinations of values of A and x that are obtained by using either the 1978 or 1999 value. Similar statements are true for (6b) and (6c) where we compute the effect of changing A and x on B .

Because of the functional form in (5), the decomposition of the change in the black incarceration rate into (6a)–(6c) is not exact. Using (5) and (6a–6c) it can be shown that

$$r_{Bi}^{1999-1978} + A_{Bi}^{1999-1978} + x_{Bi}^{1999-1978} - (B_i^{1999} - B_i^{1978}) = (0.25)(A^{1999} - A^{1978})(x^{1999} - x^{1978})Z, \tag{7}$$

where $Z = \frac{r^{1999}(r^{1999}-1)}{(r^{1999}x^{1978}+1-x^{1978})(r^{1999}x^{1999}+1-x^{1999})} - \frac{r^{1978}(r^{1978}-1)}{(r^{1978}x^{1978}+1-x^{1978})(r^{1978}x^{1999}+1-x^{1999})}$.

The right-hand side of (7) shows the amount by which the sum of our decomposition terms deviates from the actual change in black incarceration in state i . We will call this deviation the remainder. This remainder can be positive or negative and its magnitude is increasing in the magnitude of the changes in A , x , and r . However, one factor contributing to a small remainder is that changes in the demographic weights, x , tend to be small over time. During the 1978–1999 period the average magnitude of the remainder is 0.55% of each state’s change in the black imprisonment rate. During the 1999–2014 period the average magnitude of the remainder becomes 3.03%.²⁰

We can aggregate the contributions of the racial disparity, overall incarceration rates and the demographic weights to $B_{Ni}^{1999-1978}$ as follows:

$$r_N^{1999-1978} = \sum_{i=1}^{50} B_{Ni}^{1999-1978} r_{Bi}^{1999-1978} \tag{8a}$$

$$A_N^{1999-1978} = \sum_{i=1}^{50} B_{Ni}^{1999-1978} A_{Bi}^{1999-1978} \tag{8b}$$

$$x_N^{1999-1978} = \sum_{i=1}^{50} B_{Ni}^{1999-1978} x_{Bi}^{1999-1978}. \tag{8c}$$

Analogous expressions apply to the changes between 2014 and 1999.

All the expressions we have derived thus far have been in absolute terms, but we will convert these to percentages for the purposes of presenting our results. The percentage contribution of the change in the racial disparity in state i to the change in the national black incarceration rate between 1999 and 1978 is the product of the percentage contribution of the state’s black incarceration rate to the national rate, $B_{Ni}^{1999-1978}$, times the percentage contribution of the racial disparity to the change in the state’s black incarceration rate, $r_{Bi}^{1999-1978}$. Suppose

²⁰ The percentages reported in the text are obtained by taking the absolute value of the remainder and then averaging. The magnitude of the remainder tends to be larger in percentage terms when there is a small change in the black incarceration rate. Since the changes in the black incarceration rate tend to be smaller in magnitude in the 1999–2014 period, the average magnitude of the remainder is higher in this period than in 1978–1999.

$B_{Ni}^{1999-1978}$ provides 5% of the national increase in black incarceration between 1978 and 1999 and $r_{Bi}^{1999-1978}$ provides 20% of the increase in the state's black incarceration rate. Then, 1% ($= .2 \times .05$) of the increase in the nation's black incarceration rate is due to the increase in the racial disparity in state i .

Table 3 shows the state level contributions to the increase in black incarceration between 1978 and 1999, while Table 4 shows the state level contributions to the decrease from 1999 to 2014. On both tables these contributions are aggregated to both the regional and national levels.²¹ Between 1978 and 1999, the black incarceration rate increases by about 2400 per 100,000. The dominant factor in explaining the national increase in black incarceration between 1978 and 1999 is the overall increase in incarceration rates experienced in the United States. This explains 100% of the increase in black incarceration during this period.²² The rise in incarceration interacted with a large preexisting racial disparity present at the beginning of our sample in 1978, but this racial disparity does not worsen significantly over this period. More than 1/5 of the entire national increase is due to increases in the incarceration rates in Texas and California. Texas is in the South and increases in incarceration in the South led to fully 50% of the national increase in black incarceration. Note, however, that for every region of the country, increases in the overall incarceration rate contributed positively to the national increase in black incarceration. It is also notable that while the racial disparity is not contributing greatly to the increase in black incarceration during the 1978–1999 period, the worsening racial disparity in California does contribute 2.2% towards this increase. In no other state does an increase in the racial disparity contribute as much as 1% towards the national increase. Roughly half of all the states increased their black-to-white ratio while the other half decreased it over the 1978–1999 period.

During the 1999–2014 period, black incarceration fell nationally by 713 per 100,000. A positive entry during this period means the factor in question is contributing to the decline in black incarceration. Nationally, over 50% of the reduction in black incarceration is due to reductions in the racial disparity. It is notable, however, that reductions in the overall incarceration rate in California and Texas combined to explain over 50% of the reduction in the black incarceration rate during this period. When aggregating to the national level, this is partially offset by many states having an increase in their overall incarceration rate. California again stands out in terms of the racial disparity, as this contributes -3.4% to the decline in black incarceration during this period, because the racial disparity significantly increased in California between 1999–2014. California is the only state in which an increased racial disparity is a significant factor in both the 1978–1999 and 1999–2014 periods. An increased racial disparity in Texas is significant in the 1999–2014 period, but this is due to a temporary jump down in the racial disparity in Texas in 1999. (This can be seen in Fig. 3, which we discuss below.) Reductions in incarceration in New York contribute 14% to the overall drop in black incarceration, but this was accomplished without increasing the black–white disparity in the state. This stands in contrast to California. There are 5 other states which increased their black-to-white ratio over the 1999–2014 period (Colorado, Idaho, Nebraska, New Mexico, and Vermont), but the total effect from these states is less than 1/3 of the effect of the increased racial disparity in California.

²¹ For aggregation to the regional level, the summations in (8a–8c) are performed over the states within the region rather than over all 50 states.

²² While an increase in the racial disparity explains 5.3% of the increase in black incarceration, the changes in the demographic variable explain -6.8% .

Table 3 Decomposition of the increase in the national black incarceration 1978–1999^a

Region	State	Racial disparity (%)	Overall rate (%)	Demographics (%)
Midwest	Iowa	0.02	0.30	-0.02
Midwest	Illinois	0.87	5.36	-0.33
Midwest	Indiana	0.37	1.35	-0.05
Midwest	Kansas	0.01	0.57	-0.02
Midwest	Michigan	-0.49	4.93	-0.31
Midwest	Minnesota	0.07	0.24	-0.09
Midwest	Missouri	-0.31	2.48	-0.08
Midwest	North Dakota	0.00	0.01	0.00
Midwest	Nebraska	-0.10	0.19	-0.02
Midwest	Ohio	-0.36	4.82	-0.38
Midwest	South Dakota	0.00	0.02	0.00
Midwest	Wisconsin	-0.01	1.93	-0.24
Midwest		0.07	22.20	-1.53
Northeast	Connecticut	0.37	1.48	-0.20
Northeast	Massachusetts	0.01	0.01	0.00
Northeast	Maine	-0.14	0.58	-0.10
Northeast	New Hampshire	0.01	0.02	0.00
Northeast	New Jersey	0.27	4.29	-0.45
Northeast	New York	0.90	6.90	-0.85
Northeast	Pennsylvania	0.30	4.27	-0.24
Northeast	Rhode Island	0.02	0.15	-0.01
Northeast	Vermont	0.01	0.00	0.00
Northeast		1.73	17.70	-1.85
South	Alabama	0.22	3.11	-0.05
South	Arkansas	0.03	1.17	0.00
South	Delaware	0.00	0.78	-0.09
South	Florida	-0.11	4.78	-0.57
South	Georgia	0.22	3.86	-0.25
South	Kentucky	0.22	1.04	0.00
South	Louisiana	0.07	5.36	-0.34
South	Maryland	-0.19	2.76	-0.64
South	Mississippi	0.21	2.86	-0.06
South	North Carolina	0.68	1.93	0.00
South	Oklahoma	0.08	1.39	-0.06
South	South Carolina	0.53	2.02	0.01
South	Tennessee	0.18	2.02	-0.07
South	Texas	-0.82	14.34	-0.49
South	Virginia	0.19	2.47	-0.20
South	West Virginia	0.01	0.12	0.00
South		1.51	50.00	-2.82
West	Alaska	-0.03	0.08	0.00
West	Arizona	0.00	0.49	-0.02
West	California	2.17	8.62	-0.44
West	Colorado	-0.04	0.65	-0.02

Table 3 (continued)

Region	State	Racial disparity (%)	Overall rate (%)	Demographics (%)
West	Hawaii	0.00	0.05	0.00
West	Idaho	-0.01	0.02	0.00
West	Montana	0.00	0.01	0.00
West	New Mexico	-0.04	0.33	-0.03
West	Nevada	-0.01	0.08	0.00
West	Oregon	0.03	0.14	0.00
West	Utah	-0.01	0.07	0.00
West	Washington	-0.07	0.44	-0.04
West	Wyoming	0.02	0.01	0.00
West		2.01	10.98	-0.55
National ^b	National	5.32	100.88	-6.75

^aThe figures columns 3, 4 and 5 are the percentage contribution of the indicated factor to the national increase in black incarceration between 1978 and 1999. Positive entries imply the factor in question led to an increase in the national black incarceration rate

^bThe percent changes for national do not sum to 100 when adding across columns. There are two reasons. First, changes in each state's share of the black population S explain some of the changes in the national incarceration rate. Second, as shown in Eq. (7), the decomposition of the state rates contains a remainder term

The key takeaway from these tables is that an increase in the overall incarceration rate is the dominant cause of rising black incarceration between 1978 and 1999, while a falling racial disparity is the most significant source of the fall in black incarceration between 1999 and 2014. An increase in overall incarceration in the South and Midwest are the biggest regional drivers of the increase in black imprisonment during 1978–1999, while decreased racial disparities in the South and Midwest are the biggest regional drivers of the decrease in black imprisonment during the 1999–2014 period.

Estimating Structural Change Points in the Racial Disparity

In this section, we estimate the structural change points in the black–white incarceration rate ratio for the U.S. as a whole and for each individual state.²³ Finding these break points can provide clues as to the policies or events (e.g., the crack epidemic or the 1994 Crime Bill) that altered racial disparities. If there are no shifts in the value of this ratio in the years subsequent to year t , it is difficult to claim that a policy implemented in t affected the relative incarceration rate. This is important because (except for California and a few small states) we do not find any sustained positive shifts in the state data in the years following the enactment of the 1994 Crime Bill.

²³ Because there are too many missing observations, our analysis does not include Vermont.

Table 4 Decomposition of the decrease in the national black incarceration: 1999–2014^a

Region	State	Racial disparity (%)	Overall rate (%)	Demographics (%)
Midwest	Iowa	0.52	-0.32	0.28
Midwest	Illinois	2.48	-2.97	0.32
Midwest	Indiana	2.42	-3.13	0.49
Midwest	Kansas	0.38	0.02	0.13
Midwest	Michigan	0.82	1.11	0.15
Midwest	Minnesota	1.08	-1.70	0.73
Midwest	Missouri	2.57	-1.51	0.29
Midwest	North Dakota	0.06	-0.04	0.01
Midwest	Nebraska	-0.03	-0.28	0.08
Midwest	Ohio	4.09	-1.38	1.11
Midwest	South Dakota	0.04	-0.02	0.01
Midwest	Wisconsin	1.29	0.21	0.74
Midwest		15.74	-10.01	4.33
Northeast	Connecticut	1.76	0.59	0.90
Northeast	Massachusetts	0.48	0.27	0.34
Northeast	Maine	0.01	-0.03	0.01
Northeast	New Hampshire	0.06	-0.02	0.01
Northeast	New Jersey	0.08	7.46	1.11
Northeast	New York	0.47	13.96	0.93
Northeast	Pennsylvania	4.64	-8.41	1.90
Northeast	Rhode Island	0.07	-0.07	0.11
Northeast	Vermont	-0.01	-0.04	0.01
Northeast		7.56	13.71	5.30
South	Alabama	2.75	-3.87	0.49
South	Arkansas	1.47	-3.04	0.13
South	Delaware	0.72	0.59	0.38
South	Florida	9.16	-13.46	3.64
South	Georgia	2.72	-2.31	2.32
South	Kentucky	3.12	-1.46	0.23
South	Louisiana	3.23	-4.78	0.41
South	Maryland	2.29	2.24	1.55
South	Mississippi	1.74	-0.13	0.40
South	North Carolina	2.73	0.00	0.70
South	Oklahoma	1.19	-0.98	0.19
South	South Carolina	0.54	2.87	-0.24
South	Tennessee	2.61	-1.71	0.39
South	Texas	-8.01	37.47	4.34
South	Virginia	2.46	-6.16	0.62
South	West Virginia	0.29	-0.47	0.02
South		29.01	4.81	15.56
West	Alaska	0.25	-0.07	0.02
West	Arizona	1.25	-1.00	0.47
West	California	-3.39	14.09	1.34
West	Colorado	-0.57	1.22	0.14

Table 4 (continued)

Region	State	Racial disparity (%)	Overall rate (%)	Demographics (%)
West	Hawaii	0.08	-0.03	0.01
West	Idaho	-0.03	-0.02	0.00
West	Montana	0.02	-0.01	0.00
West	New Mexico	-0.30	0.51	0.02
West	Nevada	0.33	-0.03	0.39
West	Oregon	0.43	-0.44	0.03
West	Utah	0.13	0.10	0.02
West	Washington	0.86	0.10	0.19
West	Wyoming	0.12	-0.03	0.01
West		-0.81	14.41	2.65
National ^b	National	51.50	22.92	27.84

^aThe figures columns 3, 4 and 5 are the percentage contribution of the indicated factor to the national decrease in black incarceration between 1999 and 2014. Positive entries imply the factor in question led to a decline in the national black incarceration rate

^bThe percent changes for national do not sum to 100 when adding across columns. There are two reasons. First, changes in each state’s share of the black population *S* explain some of the changes in the national incarceration rate. Second, as shown in Eq. (7), the decomposition of the state rates contains a remainder term

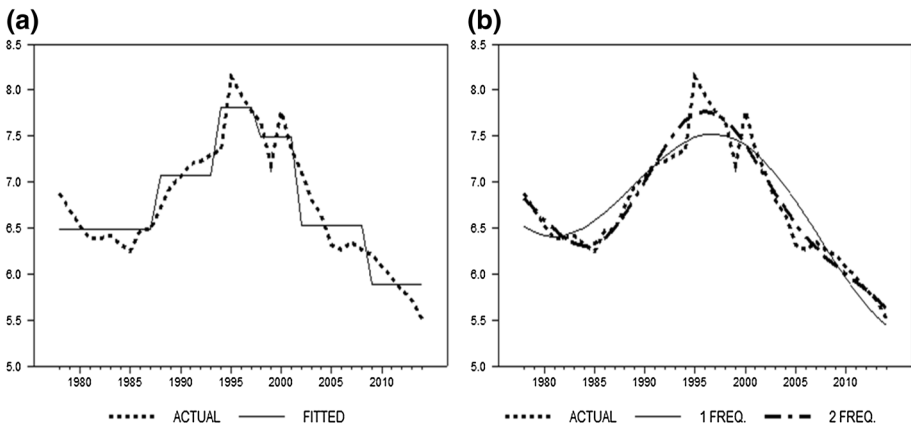


Fig. 2 Actual and fitted U.S. black/white incarceration rates. **a** Fitted using the dummy variable approach, **b** fitted using a Fourier approximation. *Note:* Actual in state custody

In the traditional time-series literature, it is standard to use a dummy-variable approach to estimate structural breaks. However, this method is not particularly suited for estimating the change points in the statewide black-to-white incarceration ratios. To explain, suppose

that one of our racial disparity variables is known to have n breaks that occur at dates $\tau_1, \tau_2, \dots, \tau_n$. As such, the usual approach is to construct n dummy variables to form:

$$r_i^t = a_0 + b_0 t + \sum_{k=1}^n a_k D_k + e(n)_t \quad (9)$$

where $r_i^t = B_i^t/W_i^t$ is our measure of the racial disparity in period t , D_k is defined as a dummy variable such that $D_k = 1$ if $t > \tau_k$, and is 0 otherwise, n is the number of breaks, $t = 1978, \dots, 2014$, a_0, b_0 and the a_k are the parameters to be estimated, and $e(n)_t$ is the approximation error. The notation $e(n)_t$ is designed to point out that the approximation error is a function of the number of dummy variables included in (9).

Of course, it is possible to incorporate other explanatory variables and/or lagged values of r_i^t into the model. However, since the break dates (i.e., the values of the various τ_k) are unknown to us, this method would necessitate estimating the break dates using a methodology such as the Bai and Perron (1998, 2003) procedure. Specifically, Bai and Perron (1998, 2003) develop an efficient algorithm to estimate every possible combination of break dates, select the combination with the greatest likelihood, and test the statistical significance of the break coefficients. However, most of the changes in our data set are actually smooth shifts so that this dummy-variable approach (i.e., assigning a break to a particular point in time) is inappropriate. To explain, the dashed line in Panel a of Fig. 2 is the time series of the actual black-to-white incarceration rate ratio when aggregating over all states. The solid line shows the fitted values using the dummy-variable approach allowing for a maximum of five potential structural breaks.²⁴ Since the actual series steadily rises from 1987 to 1994, the Bai–Perron methodology best represents this gradual increase using a step function with sharp breaks in 1987 and 1994. Similarly, the steady smooth decline after 1997 is represented by a step function with breaks in 1998, 2002 and 2009. The point is that the dummy variable approach is misspecified in the presence of smooth shifts. In particular, the number of breaks is likely to be overestimated by a step function and the associated break dates are problematic.

Since nearly all of the shifts in each state's black-to-white ratio data are gradual rather than sharp, we used a more recent approach specifically designed to capture smooth structural change. Moreover, we wanted to smooth the data since some of the series contained values that seemed overly erratic (e.g., the values in Panel a of Fig. 2 show a sharp decline in 2001 followed by a sharp increase in 2002). In particular, we utilized the type of Fourier series approximation developed in Enders and Lee (2012). By way of background, note that under very weak conditions, a Fourier approximation (i.e., a sum of simple sine and cosine waves) is able to represent any absolutely integrable function to any degree of accuracy. For each of our time series variables, r_i^t , it is possible to use a Fourier approximation to capture its behavior as:

$$r_i^t = a_0 + b_0 t + \sum_{k=1}^n a_k \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^n b_k \cos\left(\frac{2\pi kt}{T}\right) + e(n)_t, \quad (10)$$

²⁴ As such, the solid line shows the best fitting line allowing for the sharp breaks estimated by the Bai–Perron methodology. These estimates minimize the residual sum of squares. Note that the method requires us to specify a minimum number of years between successive breaks. In order to avoid fitting outliers, we specified that a break lasts no less than 5 years.

where a_0 is an intercept, b_0 is the slope of the time trend, n is the number of frequencies used in the approximation, $k = 1, \dots, n$ are the frequencies of the trigonometric terms, a_k and b_k ($i = 1, \dots, n$) are amplitude parameters, and $e(n)_t$ is the approximation error shown as a function of the number of included frequencies n .²⁵

Some of the key features of the approximation are²⁶:

1. If $n = T/2$ the fit is perfect (since the number of coefficients equals the number of observations) and if all $a_k = b_k = 0$, the series has no breaks. Moreover, as the value of n increases from 1 to $T/2$, the approximation error necessarily declines as additional regressors are added to the model. Of course, in a regression framework it is not possible to include all $n = T/2$ frequencies since the resultant estimation would contain no degrees of freedom. As such, the use of the Fourier approximation transforms the usual problem of estimating the break dates into one of selecting the most appropriate frequencies to include in the approximation.
2. Both the sine and cosine functions have a maximum of +1 and a minimum of -1. The coefficients a_k and b_k multiply the amplitude of these trigonometric waves. The parameter k represents the number of cycles the series makes over the sample period. For example, as $T = 1, \dots, 37$, $\sin(2\pi t/T)$ and $\cos(2\pi t/T)$ exhibit one complete cycle (i.e., the frequency $k = 1$) over the sample period while for $k = 2$, $\sin(2\pi 2t/T)$ and $\cos(2\pi 2t/T)$ exhibit two complete cycles. Near zero, $\sin(2\pi kt/T)$ acts like a straight line with a slope of +1 while cosine acts as a parabola opening downward. By appropriately aligning these sine and cosine functions—by using the least squares principle—it is possible to capture the behavior of almost any integral function by the appropriate choice of n .
3. Since the approximation improves as the value of n increases, the issue is to select the appropriate value of n . Enders and Lee (2012) and Enders and Jones (2014) show that a small value of n ($n \leq 3$) usually works quite well in econometric applications since gradual breaks are low-frequency events. Moreover, the values of a_k and b_k to use in the approximation can easily be obtained by estimating Eq. (10) using ordinary least squares (OLS).²⁷
4. Note that a Fourier series approximation is an orthogonal basis that fully spans the domain of the series in question. This helpful for testing purposes because each term in the approximation is uncorrelated with every other term. Moreover, in large samples with serially uncorrelated and normal errors, Gallant and Souza. (1991) show that the coefficients of (10) can be tested using a standard t -test and/or F -test.

To explain our methodology, note that the dotted line in Panel b of Fig. 2 again shows the time series of the actual black-to-white incarceration rate ratio aggregated over all states. With $T = 37$, and for $k = 1, 2, 3$ we created the six variables: $\sin 1 = \sin(2\pi t/37)$,

²⁵ Note that the sine and cosine functions have a period of $\pi/2$. As such, for the functions $\sin(2\pi kt/T)$ and $\cos(2\pi kt/T)$, the value of k is the number of complete sine and cosine cycles (i.e., the frequency) over the sample period. By appropriately aligning these sine and cosine functions it is possible to capture the behavior of almost any integral function by the appropriate choice of n .

²⁶ This discussion closely follows Enders and Jones (2014, pp. 60–61).

²⁷ Formally, structural breaks shift the spectral density function towards zero. As such, the low frequency components of a Fourier approximation can capture such shifts. Note that estimating (10) by OLS guarantees that $e(n)_t$ has mean value of zero although it is likely to be serially correlated. Enders and Lee (2012) and the survey article by Enders and Jones (2014) discuss additional details concerning the Fourier methodology.

$\cos 1 = \cos(2\pi t/37)$, $\sin 2 = \sin(2\pi 2t/37)$, $\cos 2 = \cos(2\pi 2t/37)$, $\sin 3 = \sin(2\pi 3t/37)$, $\cos 3 = \cos(2\pi 3t/37)$ and estimated regression equations of the form of (10). Our regression results for the U.S. as a whole are:

$$\hat{r}_{us}^f = 7.34 - 0.031t - 0.361 \sin 1 - 0.742 \cos 1 \tag{11}$$

(58.6) (-5.03) (-3.85) (-12.5)

$$\hat{r}_{us}^f = 7.42 - 0.036t - 0.412 \sin 1 - 0.737 \cos 1 - 0.020 \sin 2 + 0.261 \cos 2 \tag{12}$$

(71.6) (-6.75) (-5.64) (-18.9) (-0.414) (6.70)

$$\hat{r}_{us}^f = 7.55 - 0.042t - 0.491 \sin 1 - 0.731 \cos 1 - 0.060 \sin 2 + 0.268 \cos 2 - 0.094 \sin 3 + 0.001 \cos 3 \tag{13}$$

(64.4) (-7.03) (-6.14) (-19.4) (-1.16) (7.12) (-2.14) (0.038)

where \hat{r}_{us}^f denotes the fitted value of the black-to-white incarceration rate ratio aggregated for all states and t -statistics are in parentheses. The fitted values from (11) are shown as the solid line in Panel b of Fig. 2 and the fitted values from (12) are the shown by the long-dashed line.²⁸

Since our sample size is small and the errors are not normally distributed, we did not want to rely on t - or F -tests to select the most appropriate model or to eliminate any of the regression coefficients. Instead, we used a standard goodness-of-fit measure, the Akaike Information Criterion (AIC), to select the most appropriate number of frequencies.²⁹ The AIC values for Eqs. (11), (12), and (13) are -0.031 , -0.926 , and -1.07 , respectively. As such, we conclude that (13) best fits the data ($-1.07 < -0.926$) taking into account that it includes more regressors than the other equations. We then calculate the maxima and minima using the fitted Fourier values from Eq. (13). Since some of the series have several break points, each can be considered a local maximum or minimum. In addition, we identify the global maximum and minimum. In order to eliminate the possibility of fitting an outlier, a particular year is a local maximum (minimum) only if the previous 3 years and the following 3 years are each of a smaller (larger) value.

Notice that the Fourier approximation fits the data reasonably well except for the years 1995, 1998 and 1999 because the smooth Fourier function cannot readily capture very sharp changes in the data. Nevertheless, in order to properly calculate the local maxima and minima, we deemed it necessary to smooth out such seemingly erratic values in the series. More importantly, the Fourier function does fit the actual series reasonably well in that it mimics the fall in the racial disparity from the beginning of the sample until the early 1980s and also captures the subsequent rise peaking around 1996. Thereafter, the estimates series exhibits a steady decline through 2014. In order to gain some insight into the underlying reasons for the aggregate behavior, we again look at the data on a state-by-state basis.

We followed the same procedure for each of the state series in our data set and obtained the dates of the overall maximum and minimum for values for each series. Figure 3 shows

²⁸ The fitted values from (13) are not shown since they lie too close to the fitted values from (12) to be clearly visible in the figure.

²⁹ We calculated the AIC as $-2 \log(\text{likelihood})/T + 2 * (\# \text{ regressors})/T$, to determine which number of $n = 1-3$ that best fits the data for each state. Note that adding regressors improves the fit and so reduces the value of $-2 \log(\text{likelihood})$ but increases the value of $2 * (\# \text{ regressors})/T$. The regression selected is the one with the smallest value of the AIC.

the actual and fitted black-to-white incarceration rate ratios in four large states: California, Florida, Ohio and Texas. Florida, Ohio and Texas at least roughly fit the national pattern. Consistent with our earlier discussion, California runs strongly counter to the national trends. The disparity declines slightly from 1978 to the early 1990s and then doubles between the early 1990s and 2014. It is notable that California adopted its three strikes law in 1994. The data is consistent with this law having a strong racially disparate impact. However, while the data is suggestive, it in no way provides a conclusive test regarding the effects of the law.³⁰

The results for all of the states are presented in Table 5. For each state, up to three local maxima and minima are provided. Note that a local minimum implies a subsequent upturn on the black–white racial disparity, while a local maximum implies a subsequent downturn in this disparity. Table 6 summarizes the data on local maxima and minima, while Table 7 summarizes the data on global maxima and minima.

There are thirty-eight local minima reached in the 1980s, while only 6 such minima are reached in the 1990s. Conversely, 14 local maxima are reached in the 1980s, while 37 local maxima are reached in the 1990s. This implies that in many states there was an upturn in the racial disparity in the 1980s and for many states there was a downturn beginning in the 1990s. In the 2000–2011 period, there are an equal number of local maxima and minima, 24. To get some potential insight on the effects of the 1994 crime bill on the racial disparity, Table 6 also summarizes the data for 1984–1993 and 1995–2004, the 10 years prior and subsequent to the passing of the law. In the 1984–1993 period, 31 local minima and 21 local maxima are reached. Thus, in the years prior to the passage of the bill, upturns in the racial disparity outnumber downturns by about 50%. In the 1995–2004 period, there are 9 local minima and 34 local maxima. Thus, in this period downturns in the racial disparity greatly outweigh upturns in the racial disparity. In 1995, the year after the 1994 crime bill takes effect, there are 13 maxima and 0 minima. It is also notable that the aggregate disparity (Fig. 2) turns down beginning in 1996 and declines until the end of our sample. While for many states a downturn in the racial disparity begins in the 1990s, this does not imply that the 1994 crime bill was causal in this pattern. In particular, the minima become less frequent by the late 1980s and maxima begin to occur by the early 1990s even before this bill is signed. However, there is no evidence based on these results that the 1994 bill aggravated the racial disparity.³¹

Table 7 summarizes the timing of the global maxima and minima. Twenty-seven global maxima are reached in the 1990s. During the 2000–2014 period, 29 global minima are reached, while only 7 global maxima are reached. For 26 states, 2014 marks the global minima for the racial disparity, so that in more than half the states the lowest value for the racial disparity is observed at the end of the sample period. The latest date for a global maximum is 2012, which is for California.³²

³⁰ Twenty-four states enact three strikes statutes in the 1993–1995 period, while only a handful experience a subsequent rise in the racial disparity. However, the details of the laws differ by state and California had a particularly stringent version of the law. As of July 1998, California had more persons sentenced under this statute on a per capita basis than any other state. See Marvell and Moody (2001, fn. 27 and p. 102).

³¹ We cannot conclusively rule out the possibility that the aggregate racial disparity would have fallen faster absent the 1994 bill. We can only conclude that the prima facie evidence does not support the idea that the bill aggravated the racial disparity in state level imprisonment.

³² In addition to California, the other states reaching a global maximum in the racial disparity in the 2000–2014 period are Colorado, Maine, New Jersey, New Mexico, New York, and North Dakota.

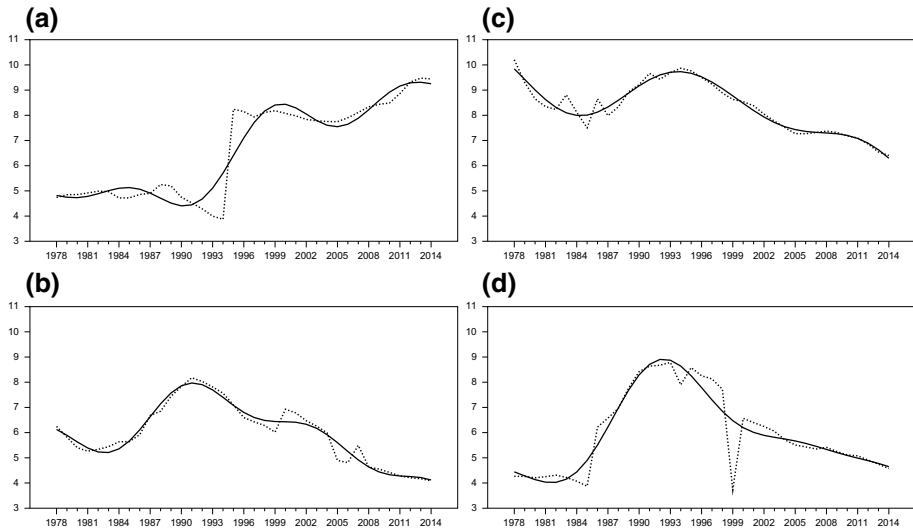


Fig. 3 Black/white incarceration rates in four key states. **a** California, **b** Florida, **c** Ohio, **d** Texas

The general upturn in the racial disparity in the 1980s is likely due to the emergence of the crack epidemic. There is ample evidence that the epidemic had a racially disparate impact (Fryer et al. 2013; Evans et al. 2016; Bjerk 2017). In addition to the violence surrounding the drug trade, the sentencing disparity between crack and powder cocaine is consistent with an increased racial disparity in imprisonment during this period.³³ As the effects of the crack epidemic wane, we see a general downturn in the racial disparity beginning in the 1990s. However, California is a large state that runs counter to the national trend, with a significant worsening in its racial disparity beginning in the early 1990s and continuing until near the end of our sample. At the end of our sample in 2014, the black to white incarceration ratio is still extraordinarily high at 5.5. Note that over the first 21 years of our sample, from 1978 to 1999 this ratio actually rises slightly from 6.9 to 7.1. All of the net decline occurs in the last 15 years of the sample over which the ratio declines from 7.1 to 5.5. Whether or not this recent downward trend can be maintained is an open question.

Conclusion

This paper has largely been a descriptive analysis of how the racial disparity in imprisonment in the United States varies across states and time. The analysis focuses on non-Hispanic black and white males. Our sample period begins in 1978 at which time the

³³ Presumably both factors contribute to the increased racial disparity during this period, but our analysis does not allow us to put weights on these two factors. Because we use state level data, the Federal sentencing disparity is not directly relevant. However, 16 states introduced sentencing disparities between crack and powder cocaine. See Porter and Wright (2011). At the time of the writing of their report in 2011, three states had passed legislation to remove this disparity.

Table 5 Structural change points in the racial disparity

Region	State	Global max	Max value	Global min	Min value	n	Local min 1	Local min 2	Local min 3	Local max 1	Local max 2	Local max 3
Midwest	IA	1995	17.63	2014	11.88	3	2004			1995	2009	
Midwest	IL	1995	14.09	1978	8.2	3	2011			1995		
Midwest	IN	1996	8.71	1978	4.57	3	1987			1984	1996	
Midwest	KS	1995	10.01	2014	7.65	2	1984			1995		
Midwest	MI	1978	10.44	2007	6.83	3	2007					
Midwest	MIN	1995	25.26	2014	12.94	3	1985	2004		1995	2010	
Midwest	MO	1978	10.54	2014	4.09	3	1984	2007		1991	2010	
Midwest	ND	2007	8.01	1978	1.01	3	1989	2002		1984	1997	2007
Midwest	NE	1980	14.88	2000	8.78	3	1987	2000	2011	1992	2006	
Midwest	OH	1994	9.74	2014	6.37	2	1984			1994		
Midwest	SD	1978	8.58	2014	5.97	0						
Midwest	WI	1997	17.53	1988	13.1	3	1988	2006		1997	2010	
Northeast	CT	1992	18.65	1978	8.82	2				1992		
Northeast	MA	1978	14.29	2014	7.01	3	1983	2006		1989	2010	
Northeast	ME	2000	6.84	1986	2.83	2	1986	2008		2000		
Northeast	NH	1995	8.62	1983	2.94	2	1983	2005		1995	2008	
Northeast	NJ	2003	17.25	1978	10.98	2	1989			1985	2003	
Northeast	NY	2002	13.87	1992	4.99	3	1984	1992		1988	2002	
Northeast	PA	1996	17.11	2012	10.68	3	1986			1983	1996	
Northeast	RI	1997	13.14	2014	9.69	1				1997		
South	AL	1995	5.86	2014	4.06	2	1982			1995		
South	AR	1995	6.95	2014	4.25	2	1985	2006		1995	2010	
South	DE	1992	9.88	2014	4.75	3	1984	2000		1992	2004	
South	FL	1991	7.99	2014	4.14	3	1982			1991		
South	GA	1993	5.67	1983	3.84	3	1983	2007		1993		
South	KY	1997	7.96	2014	3.51	3	1989			1985	1997	

Table 5 (continued)

Region	State	Global max	Max value	Global min	Min value	<i>n</i>	Local min 1	Local min 2	Local min 3	Local max 1	Local max 2	Local max 3
South	LA	1995	7.49	2014	4.64	3	1987			1981	1995	
South	MD	1978	12.1	2014	5.04	3	1985			1993		
South	MS	1995	5.66	1978	3.55	3	1987			1984	1995	
South	NC	1995	7.54	1982	4.15	2	1982			1995		
South	OK	1995	7.05	2014	4.93	3	1982	2003		1995	2009	
South	SC	1997	5.73	1981	3.34	2	1981			1997		
South	TN	1998	5.78	1985	4.15	2	1985			1998		
South	TX	1992	8.88	1982	4.03	3	1982			1992		
South	VA	1995	8.13	2014	5.62	2	1983			1995		
South	WV	1978	6.45	2014	3.58	3	1984			1999		
West	AK	1978	5.89	2014	2.92	3	1985	2006		1998	2009	
West	AZ	1978	8.18	1994	4.43	3	1986	1994	2009	1989	2002	2011
West	CA	2012	9.35	1990	4.38	3	1990	2005		1985	1999	
West	CO	2004	8.52	1986	5.67	1	1986			2004		
West	HI	1978	2.97	2014	1.74	3	1986	2001		1993	2007	
West	ID	1982	7.47	1991	3.49	3	1991	2001	2011	1982	1996	2008
West	MT	1978	8.91	2014	4.56	1	1992			2004		
West	NM	2003	9.88	1993	2.72	3	1984	1993		1988	2003	
West	NV	1987	7.03	2014	4.35	3	2004			1987	2010	
West	OR	1991	9.65	2014	5.26	3	1983	2007		1991	2010	
West	UT	1978	13.3	2014	7.72	1						
West	WA	1978	8.96	2014	5.45	1	1988			1995		
West	WY	1998	8.14	2014	3.34	1	1983			1998		

Table 6 Local maxima and minima

Period	Minima	Maxima
1980–1989	38	14
1990–1999	6	37
2000–2011 ^a	24	24
1984–1993	31	21
1995–2004	9	34

^aSince our procedure requires three subsequent periods to determine a minima or maxima, 2011 is the last possible date to observe either a maxima or minima

Table 7 Global maxima and minima

Period	Minimum	Maximum
1978–1989	15	15
1990–1999	5	27
2000–2014	29	7

black incarceration rate was 6.9 times the white rate. While this ratio initially falls, it begins a sustained increase in the early 1980s and peaks at a value of 8.1 in 1995. Since reaching this peak, there has been a sustained decrease in the racial disparity down to a level of 5.5 in 2014. While the sustained decrease in the racial disparity is welcome, it is still very large at the end of the sample period.

Between 1978 and 1999 there is a massive increase in the black incarceration rate from 1080 to about 3500. The racial disparity did not change much over this period and the increase in incarceration was overwhelmingly due to an increase in the overall incarceration rate. The very large increase in the black imprisonment rate is only partially offset during the 1999–2014 period, and during this period a reduction in the racial disparity explains over 50% of the fall in black imprisonment.

Many upturns in the racial disparity are concentrated in the 1980s and it is possible that this is connected to the crack epidemic. Many downturns in this rate occur in the 1990s including the period after the 1994 Crime bill became law. Whatever the other effects of this bill, there is no prima facie evidence that it exacerbated the racial disparity in imprisonment at the state level. For more than half the states, the lowest observed value of the racial disparity occurs in the last year of the dataset. While the racial disparity remains large, it is at least somewhat encouraging that it has generally been falling since the 1990s. It is notable that the experience in California runs counter to the national trend with a large increase in the racial disparity beginning in the early 1990s and continuing until near the end of our sample.

We have used a Fourier approximation to gain insight into the time series behavior of the racial disparity. This method can be widely applied within criminology whenever it is believed that the data exhibit gradual shifts over time. For example it can be applied to an analysis of overall incarceration rates rather than just the racial disparity. It can also be applied to data such as prison admissions, crime rates and arrest rates among others. A better understanding of the time series behaviors of these variables can, in turn, help provide insight into how federal and state policy impacts the criminal justice system.

Our approach is largely descriptive and it does not allow for formal testing of how policies such as truth in sentencing or three strikes laws have affected the racial disparity. These policies could be formally analyzed in a panel data analysis. The effect of these policies on incarceration has previously been analyzed in a panel setting, but to date this has not been done for the racial disparity.³⁴ Thus, this is a potentially fruitful avenue for future research. Such work may shed light into how the racial disparity in imprisonment can be further reduced.

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³⁴ See, for example, Stemen et al. (2005).

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