

# Homicide in Black and White\*

Brendan O’Flaherty<sup>†</sup>

Rajiv Sethi<sup>‡</sup>

January 15, 2010

## Abstract

African-Americans are six times as likely as white Americans to die at the hands of a murderer, and roughly seven times as likely to murder someone. Young black men are fifteen times as likely to be murdered as young white men. This disparity is historic and pervasive, and cannot be accounted for by individual characteristics. Culture-of-violence and tail-of-the-distribution theories are also inadequate to explain the geographic and demographic pattern of the disparity. We argue that any satisfactory explanation must take into account the fact that murder can have a preemptive motive: people sometimes kill simply to avoid being killed. As a result, disputes can escalate dramatically in environments (endogenously) perceived to be dangerous, resulting in self-fulfilling expectations of violence for particular dyadic interactions, and significant racial disparities in rates of murder and victimization. Because of strategic complementarity, small differences in fundamentals can cause large differences in murder rates. Differences in the manner in which the criminal justice system treats murders with victims from different groups, and differences across groups in involvement in street vice, may be sufficient to explain the size and pattern of the racial disparity.

---

\*We thank the Santa Fe Institute and the Institute for Advanced Study at Princeton for financial support and hospitality.

<sup>†</sup>Department of Economics, Columbia University.

<sup>‡</sup>Department of Economics, Barnard College, Columbia University and the Santa Fe Institute.

# 1 Introduction

African-Americans are roughly six times as likely as white Americans to die at the hands of a murderer, and roughly seven times as likely to murder someone; their victims are black 82% of the time.<sup>1</sup> Homicide is the second most important reason for the racial gap in life expectancy: eliminating homicide would do more to equalize black and white life expectancy than eliminating any other cause of death except heart disease. Using standard life-valuing estimates, young white men would have to be paid about \$4000 a year to endure the threat of being murdered that young black men face.<sup>2</sup> About 72,000 black men were held in state prisons on homicide charges (murder and manslaughter) in 2003, amounting to 13% of the total black prison population (Bureau of Justice Statistics, 2006).

We argue here that this extraordinary concentration of homicides in the black community cannot be fully understood without recognizing that murder is a crime for which there is a powerful preemptive motive: people sometimes kill simply to avoid being killed. This is the case in war, and is also the case in some urban war zones. Ordinary people in ordinary circumstances have little or nothing to gain from killing other people, and high murder rates can generally be sustained only if some people kill for self-protection. The more dangerous the environment in which a person lives, the more likely he is to kill, holding constant his individual attributes. But the level of danger in an environment is itself endogenous, fueled by the extent of perceived danger or fear. Murders make for a tense situation, and in tense situations, people are quick to commit murder. A significant proportion of homicides result from the escalation of disputes between acquaintances or strangers who have limited information about each other's personal characteristics.<sup>3</sup> Under such circumstances expectations of violence can become self-fulfilling for particular types of dyadic interaction, and large racial disparities in rates of murder and victimization can be sustained.

The magnitude of the difference in murder and victimization rates far exceeds any difference in characteristics that appear to predispose people to kill and be killed: being poor, being a high-school dropout, living in a dense urban environment, or being raised in a single-parent household, for instance. Blacks are about 2.75 times as likely as whites to be poor, 2.2 times as likely to be high-school dropouts, 2.9 times as likely to live in a large city, and 2.7 times as likely to grow up in a single parent household—all ratios that are far below the observed ratios for murder victimization and offending.<sup>4</sup> Moreover, the racial homicide gap is long-lasting and widespread, and is much

---

<sup>1</sup>US Bureau of Justice Statistics (2007). The comparison is for 2004.

<sup>2</sup>In 2003, the death rate from homicide for black men aged 15-25 was 77.6 (per 100,000 population), while for white men in the same age group it was 4.7. The corresponding figures for the 25-34 age group were 81.6 and 5.5 respectively (National Center for Health Statistics, 2006, table 45). Using the Aldy-Viscusi (2003) estimate of \$5-7 million per statistical life, these differences imply a range of \$3645 to \$5327 per year. This difference was considerably larger in the 1980s.

<sup>3</sup>See Section 2 below for evidence on circumstances, motives, offender-victim relationships, and the persistence and pervasiveness of racial disparities in murder and victimization rates.

<sup>4</sup>In 2005-2007, the American Community Survey found 25.3 percent of black individuals to be poor, as compared with 9.18% of non-Hispanic white individuals. The poverty disparity was less among the age-gender groups most likely to be murdered. For men 25-34 years old, blacks were 2.06 as likely to be poor as whites (U.S. Bureau of the Census, 2009a). Information on dropouts is from the Current Population Survey of March 2006 (U.S. Bureau of the Census, 2009b). For 25-29 year-olds, the ratio was 2.17 for men and 2.26 for women. Density is based on the

greater in cities and among young men than in other places or among other age-gender groups. In rural areas, there is no racial disparity in murder. The homicide gap is also much larger than the racial disparity in aggravated assault—in some ways the crime closest to murder—and there is no racial disparity in aggravated assault among young men. We argue below that this pattern is inconsistent with explanations that emphasize Southern heritage, a culture of violence, or group differences in the distribution of individual characteristics. Explaining why the disparity is so great is the goal of this paper.

We begin with a baseline model in which race is the only visible characteristic, and the distribution of unobserved characteristics may differ across groups. In this setting, we explore two possible mechanisms through which significant racial disparities in homicide rates can arise. First, suppose that the costs of committing murder are contingent on the identity of the victim, with murders less likely to be solved and less aggressively prosecuted if the victims are black. In this case one would expect blacks to be victimized at greater rates, other things equal. But this means that blacks face greater danger in all their interactions, and are more likely therefore to kill preemptively. Anticipating this, whites will be more likely to kill preemptively in interactions with blacks than in interactions with other whites. The effect is strongest when both participants to a dispute are black, and we show that the hypothesis of victim-contingent costs implies that one can provide a complete ranking of levels of violence, with black on black interactions being most likely to end in murder and white on white interactions being least likely.

The second mechanism is based on costs of murder being contingent on the identity of the offender rather than the victim. Systematically lower incomes and higher rates of unemployment among blacks make the penalties for attempted murder or manslaughter lower for blacks relative to their outside options.<sup>5</sup> Furthermore, the marginal penalties for murder are lower for those who are already engaged in high risk criminal activities such as drug-selling and robbery, and black overrepresentation in such activities is significant.<sup>6</sup> As in the case of victim-contingent costs, this can induce cascading expectations of preemptive violence in interactions involving blacks, relative to the case when a dispute involves only whites, and result not just in higher rates of killing but also in higher rates of murder victimization. The hypothesis of offender-contingent costs also implies a complete ranking of levels of violence, with black on black interactions being most likely to end in murder and white on white interactions being least likely.

While the above considerations pin down the likelihood of violence conditional on the identities of the individuals involved, aggregate rates of homicide and victimization will depend also on the frequency with which members of different groups come into contact with each other. This depends on the level of segregation in social interactions, as well as the demographic composition of the population at large. Our model makes clear predictions regarding the relationship between segregation

---

proportion of the population living in cities with more than 250,000 people in the 2000 census (U.S. Bureau of the Census, 2004, tables 32 and 33). At that time, 31.6 percent of blacks and 10.8 percent of non-Hispanic whites lived in these cities. For children under 18 in the March 2008 Current Population Survey, 22.2 percent of non-Hispanic whites and 60.9 percent of blacks were not living with both parents (U.S. Bureau of the Census, 2009c, table C3).

<sup>5</sup>Balanced against this is the possibility that offenders may be more aggressively pursued and prosecuted if they are black, holding constant the identity of the victim.

<sup>6</sup>We have discussed reasons for this overrepresentation elsewhere; see O’Flaherty and Sethi (2008, 2010b) for robbery and street vice respectively.

and murder: more segregated cities, other things equal, will have greater racial disparities in rates of murder as well as rates of victimization. The model also predicts that cities with larger black populations will have higher murder rates among both blacks and whites.

An interesting implication of our analysis is that policies that are specifically targeted at improving welfare among blacks can also benefit whites. For instance, if crimes involving black victims were to be more aggressively investigated and prosecuted, this would not only lower black murder and victimization rates, it would also reduce preemptive killing in interactions between blacks and whites, thereby lowering white murder and victimization rates. Similar effects arise through improved outside options for blacks, which raise the relative costs of attempted homicide: even those whose costs of killing are unchanged will kill less often because they have less to fear from others. Hence whites can benefit from policies specifically targeted at improving black welfare.<sup>7</sup>

While the baseline model identifies mechanisms through which small differences across groups can be amplified, it suffers from two drawbacks. First, it implies, contrary to fact, that the racial disparity within groups in which homicide is more common (such as young men) will be smaller than the racial disparity within groups in which homicide is rare (such as elderly women). Second, it is built on the simplifying but counterfactual assumption that within-group interactions are random and the behavior is conditioned only on race and on no other observable characteristics. We therefore extend the model in to allow for assortative interaction by occupation as well as costly investments in lethality. Those engaged in street vice have lower costs and higher benefits from committing murders, and they tend to interact with other others in the same business. Hence they are more inclined to make costly investments (such as the acquisition of firearms) that make the subsequent use of violence cheaper. Moreover, among those engaged in street vice, blacks are more likely than whites to meet partners who are similarly employed, because a larger fraction of blacks are employed in the industry. Hence blacks in the vice business have a higher murder rate than whites in the same business for two reasons: because they are more likely to meet others who are similarly employed, and because they are more likely to make preemptive investments in lethality.

The idea that incomplete information about the preferences of others can result in preemptive killing even when both parties to a dispute prefer a peaceful resolution appears in Schelling's famous discussion of a burglar in the house as an analogy for the Cold War (Schelling, 1960). Baliga and Sjoström (2004) formalized this idea as a game of incomplete information and identified precisely the conditions under which mutual violence arises as a unique (but highly inefficient) equilibrium; see also Baliga, Lucca, and Sjoström (2007). We have extended this work to a setting with different choices of lethality and applied it to changing murder rates in Newark, New Jersey (O'Flaherty and Sethi, 2010a). Here we build on this earlier work by allowing for the possibility that behavior is contingent on racial identity.

In looking at the comparative statics of segregation on a dimension of racial inequality we follow Chaudhuri and Sethi (2008), who explore the effect of segregation on negative stereotypes, and Bowles et al. (2008) who examine the relationship between segregation and group inequality

---

<sup>7</sup>Similarly, men can benefit from policies specifically designed to protect women from violence. The proportion of intimate partner homicide victims who were male was 46% in 1976, and declined steadily to reach 28% by 1998. Over this period "the number of male victims of intimate partner homicide fell an average 4% per year and the number of female victims fell an average 1% (Rennison and Welchans, 2000).

in the distribution of human capital. Those papers identified conditions under which integration could improve welfare among both blacks and whites, and thus receive widespread popular support. In our context here, however, integration unambiguously raises rates of offending and victimization among whites while lowering these rates for among blacks. Nevertheless, as noted above, there are policies targeted at blacks that can result in lower murder and victimization rates in both populations.

This paper is also related to the literature on social multipliers (Glaeser, Sacerdote, and Scheinkman, 1996, 2003; Goldin and Katz, 2002; and Becker and Murphy 2000). Strategic complementarity in levels of violence, coupled with some degree of segregation in social contact, implies that group differences are larger than would be expected based on the distributions of individual characteristics alone. Fear is the social multiplier that drives our results, since it induces a preemptive response that heightens the level of danger and amplifies the level of fear.

## 2 Motivating Evidence

### 2.1 Persistence

Blacks have been considerably more likely than whites to be killed by murderers in the US for as long as good records have been available. In 1910, when decent records start, the black (precisely, nonwhite) murder victimization rate was about 22 per 100,000, and the corresponding white rate was around 5 per 100,000—a ratio of about 5 to 1 (Shin et al., 1977). In 2004, the situation was not much different: the black victimization rate was 20.1 per 100,000 and the white rate was 3.6 for a ratio of about 5.6 to 1 (National Center for Health Statistics, 2006, table 29; these are age-adjusted rates with a 2000 base). After 1910, the black rate rose rapidly, probably with urbanization, until it was about 10 times the white rate by the mid 1920s. Both rates fell during the Great Depression—or with the end of Prohibition—but the ratio stayed about the same.

Table 1: Homicide Victimization Rates by Race and Gender, 1950-2004, per 100,000 population (age-adjusted, using 2000 age distributions as the base)

	Men					Women				
	Black	White	Ratio	NHW	Ratio	Black	White	Ratio	NHW	Ratio
1950	47.0	3.8	12.4			11.1	1.4	7.9		
1960	42.3	3.9	10.8			11.4	1.5	7.6		
1970	78.2	7.2	10.9			14.7	2.3	6.4		
1980	69.4	10.4	6.7			13.2	3.2	4.1		
1990	63.1	8.3	7.6	5.6	11.3	12.5	2.7	4.6	2.5	5.0
2000	35.4	5.2	6.8	3.6	9.8	7.1	2.1	3.4	1.9	3.7
2004	35.1	5.3	6.6	3.6	9.8	6.3	1.9	3.3	1.8	3.5

Source: National Center for Health Statistics, 2006, table 45

Table 1 shows how murder rates have evolved since 1950. The story about levels in the table is consistent: black rates are always higher than white rates, and male rates are always higher than female rates. Race is more powerful than gender: black women are more likely to be murdered than white men. The ratios, however, trend downward: blacks are becoming more like whites. Immigration is responsible for part of this convergence for men. If Hispanics are separated from non-Hispanic whites (NHW), male ratios are still close to 1970 levels in 2004, but the trend is still down from 1980 to 2004. On the other hand, the rate of convergence since 1980 is very slow. Most of the convergence in both male and female ratios occurred between 1950 and 1980.

For murder offending, we have a shorter time series, and a less complete one, because offenders are not identified for every murder. Since most homicide is intraracial, offending rates for earlier periods were probably not very different from victimization rates. Table 2 gives offending rates by race since 1976, based on FBI reports. The ratios are consistently higher than the ratios for victimization (the African-American community exports murder to a small extent), and have a weak downward trend, interrupted by a rise in the late 1980s (which Fryer et al., 2005, attribute to crack cocaine). Convergence in victimization rates had almost come to an end by 1976 when this series starts, and so the trend in offending is not seriously different from the trend in victimization.

Table 2: Homicide Offending by Race, 1976-2005, per 100,000 population

	Black	White	Ratio
1976	46.6	4.9	9.5
1980	51.5	6.4	8.1
1984	33.1	5.3	6.3
1988	41.2	4.9	8.4
1992	47.0	5.2	9.0
1996	35.9	4.5	8.0
2000	25.6	3.5	7.3
2004	24.1	3.6	6.7
2005	26.5	3.5	7.6

Source: US Bureau of Justice Statistics, 2007

The time series indicates that we cannot attribute the racial disparity in murder to any recent phenomenon, like crack or television or single parenting. The convergence in murder rates follows a temporal pattern broadly similar to those for male wages (Chandra, 2003) and educational achievement (Neal, 2005), and so we cannot portray the disparity as immutable.

It is instructive to compare black homicide victimization rates to those of Hispanics. Hispanics are more likely to be murdered than non-Hispanic whites, but are considerably less likely to be murdered than non-Hispanic blacks. The total victimization rate for whites was 2.7 per 100,000 population in 2004; the corresponding figures for Hispanics and blacks were 7.2 and 20.1 respectively. Disparities are even greater for young men, the demographic group most likely to be murdered. In 2004, white and black victimization rates for men aged 25-34 were 5.5 and 81.6 respectively, while

for Hispanics men in this age group the rate was below 30 (Health, United States, 2006, tables 29 and 45).

Such a relatively low murder victimization rate seems surprising, since the two groups have similarly high poverty and dropout rates.<sup>8</sup> Part of the disparity could be due to the fact that the Hispanic murder rate is measured with considerable error. The denominator is the self-assessed Hispanic population in the Census or a similar survey, while the numerator is constructed by medical examiners who use whatever evidence they have at hand. Nevertheless, since the reported Hispanic murder victimization rate is roughly a third of the black murder victimization rate, measurement error is probably not the whole story.

One major difference between blacks and Hispanics is the proportion of the population that is foreign-born.<sup>9</sup> For several reasons, foreign-born individuals are less likely to engage in criminal activities of any kind. Legal foreign born residents are screened before they enter the U.S. (except for Cubans); past criminal activity precludes entry. Immigrants from many countries may also be self-selected: relative to many immigration source countries, the opportunities for pursuing legal jobs and opportunities may be relatively better in the United States than the opportunities for criminal careers. Deportation acts as a second screening device, one which screens illegal as well as legal entrants. Those who have been deported cannot commit second crimes in the U.S. or engage in U.S. illegal businesses, without paying the considerable costs of re-entry. (Naturalized citizens cannot be deported, but they are screened by the requirement that they maintain a clean record in the US for an extended period before they qualify for citizenship.) Ex ante, the threat of deportation raises expected penalties of crime for all foreign-born residents who are not naturalized. In a competitive industry such as drug selling, these added penalties place those who bear them at a considerable disadvantage, since employers will not pay them wages above those at which natives are willing to work. Foreign-born non-citizens will accordingly be underrepresented in illegal businesses.

There is reasonably good evidence that these considerations make the foreign-born population of the U.S. less likely to work in illegal businesses than the U.S.-born population. Butcher and Piehl (2008) found that in California in 2005 U.S.-born men had incarceration rates 2.6 times higher than those of foreign-born men (most of whom were Hispanic), and U.S.-born women had incarceration rates almost four times as great as those of foreign-born women. The rate of incarceration for drug crimes was 54 per 100,000 for the foreign-born, 114 per 100,000 for the U.S.-born. In a separate paper, Butcher and Piehl (2007) examine the evidence on why immigrants are so extremely law-abiding and conclude that selective immigration is more important than deportation or deterrence.

Thus we have several reasons to believe that the marginal penalties for killing are greater for Hispanics than for blacks. By the logic of the model developed here, they will be less likely to be killed preemptively, resulting in lower rates of homicide victimization. Relative rates could change as the Hispanic population becomes more U.S.-born, or criminal justice in home countries improves,

---

<sup>8</sup>In the American Community Survey for 2006, table 8, 21.5% of Hispanics were living in poor households, as compared with 25.3% of blacks, and 37.2% of Hispanic men 18-24 had not completed high school in 2005, as opposed to 26.3% of black men.

<sup>9</sup>In the 2005 American Community Survey, 40.1% of the Hispanic population and 7.7% of the black population was foreign-born.

or immigration laws and their manner of enforcement change.

## 2.2 Age and Gender

Although the overall level of homicide varies significantly by age and gender, the black-white murder disparity is evident in all groups. Everywhere we look we find more black murders than white.

Table 3 compares black and (non-Hispanic) white homicide victimization rates by age and gender, and Table 4 does the same for offending rates. The ratio is highest for the age-gender groups where murder is most common, but even for age-gender groups where murder is relatively rare, blacks are still considerably more likely to kill and be killed than whites.

Table 3: Homicide Victimization by Age and Gender, 2004, per 100,000 population

Age	Men			Women		
	Black	NHW	Ratio	Black	NHW	Ratio
< 1	14.2	6.1	2.32	17.0	5.8	2.93
1-14	3.5	0.8	4.38	2.8	0.7	4.00
15-24	77.6	4.7	16.51	8.8	2.3	3.83
25-34	81.6	5.5	14.84	9.4*	2.5*	3.76*
35-44	37.9	5.0	7.58	9.4*	2.5*	3.76*
45-64	22.0	3.8	5.79	5.1	1.6	3.19
> 65	11.0	2.4	4.59	2.9	1.6	1.81

\*25-44. Source: Health, United States, 2006, table 45.

Table 4: Homicide Offending by Age and Gender, 2005, per 100,000 population

Age	Men			Women		
	Black	White	Ratio	Black	White	Ratio
14-17	64.1	7.9	8.11	4.0	0.7	5.71
18-24	203.3	22.4	9.08	11.8	2.0	5.90
> 25	41.8	5.5	7.60	4.0	0.8	5.00

Source: US Bureau of Justice Statistics, Homicide Trends

The pattern where the racial disparity is greatest for the age-gender groups for whom murder is most common suggests that a simple story about the tail of a distribution is insufficient to explain the racial murder gap. The tail-of-the-distribution theory argues that since murder is a rare event, it can be modeled as a draw from the tail of a distribution—to be concrete, say the extreme left tail of a normal distribution. Even though the black and white distributions of some underlying variable may be fairly close together, as long as they have the same variance and the black mean

is slightly lower than the white, the ratio of black probability mass to white probability mass less than a particular value becomes arbitrarily and monotonically large as that value decreases.

For instance, suppose both distributions are normal with variance one, the white mean is one, and black mean is zero. Then the probability that the black value is less than 0.7 is approximately twice the probability that the white value is less than 0.7. However, the probability that the black value is less than  $-0.8$  is approximately six times the probability that the white value is less than  $-0.8$ . Thus suppose disputes become aggravated assaults when their severity is worse than 0.7 on some scale where more severe disputes are assigned lower numbers; they become murders when the severity is worse than  $-0.8$ . If the severity of black disputes is normally distributed with mean zero and standard error one, while the severity of white disputes is normally distributed with mean one and standard error one, then blacks will be six times as likely as whites to be murder victims, and twice as likely to be aggravated assault victims. These are approximately the observed ratios.

To see why the tail-of-the-distribution theory cannot account for the observed pattern of homicides by age and gender, consider the following. Let  $\Phi$  be a distribution function and let  $\phi$  denote the corresponding density. For any  $\mu > 0$ , define the likelihood ratio as

$$L(x) = \frac{\phi(x + \mu)}{\phi(x)}.$$

We say that the distribution satisfies the monotone likelihood ratio property (MLRP) if  $L(x)$  is an increasing function for any  $\mu > 0$ . Define  $R(x)$  as follows:

$$R(x) = \frac{\Phi(x + \mu)}{\Phi(x)}.$$

Then the following holds (see the appendix for the proof of this and all other formal claims):

**Likelihood Ratio Proposition:** If  $\Phi$  satisfies MLRP then (i) for any  $\mu > 0$ ,  $R(x)$  is monotonically increasing in  $x$ , and (ii) if  $\lim_{x \rightarrow -\infty} L(x) = -\infty$  then  $\lim_{x \rightarrow -\infty} R(x) = -\infty$ .

The difficulty with the tail-of-the-distribution theory is that it implies that the racial disparity should be least among age-gender groups with the highest murder rates, while the opposite is true. Suppose the murder threshold is  $x$ , and compare old men with young men. Suppose the severity of disputes has mean  $y$  and  $o$  for young and old men black men respectively, with  $y < o$  so that young men are murdered more frequently than old men. Let the distributions for young and old white men have means  $y + w$  and  $o + w$  respectively, where  $w > 0$ . All distributions have the same variance. Thus the probability of murder for young black men is  $\Phi(x - y)$  and the probability of murder for young white men is  $\Phi(x - y - w)$ . The ratio of black to white murder rates among young men is

$$R_y = \frac{\Phi(x - y)}{\Phi(x - y - w)}$$

Similarly, the ratio for old men is

$$R_o = \frac{\Phi(x - o)}{\Phi(x - o - w)}$$

which is greater than  $R_y$  by the likelihood ratio proposition. Hence the tail-of-the-distribution theory cannot explain the age-gender pattern of relative racial murder rates.<sup>10</sup>

---

<sup>10</sup>Note that we have assumed here not only that the distributions all have the same variance, but also that the

## 2.3 Circumstance

Next, consider circumstances. The most straightforward comparisons are for 1980 in Wilbanks (1986); composite data from the US Bureau of Justice Statistics (2007) are more difficult to interpret in terms of rates but give the same picture. Table 5 summarizes the Wilbanks data. Notice that once again no ratios are below 2, and most are above 5. Among black murders, for instance, domestic violence is a relatively rare circumstance, but still blacks are more likely to die from domestic violence than are whites. Most importantly, most murders result from arguments or disputes that escalate, and most involve interactions between acquaintances and strangers rather than intimates or family members.

Table 5: Circumstance/Relationship by Race of Offender, 1980, per 100,000 population

Circumstance	Black	White	Ratio
Felony (mainly robbery)	5.40	0.35	10.1
Vice (except narcotics)	0.30	0.11	2.9
Narcotics	0.55	0.07	7.9
Lovers' triangle	0.80	0.13	6.2
Brawl, narcotics or alcohol	1.33	0.33	4.0
Arguments	16.38	1.87	8.8
Gang	0.18	0.08	2.3
Relationship			
Acquaintance	13.99	1.71	8.2
Lover/spouse	4.78	0.68	7.0
Other family	2.37	0.52	4.6
Stranger	6.14	0.77	8.0

Source: Wilbanks (1986), tables I and II.

## 2.4 Geography

The disparity is also ubiquitous geographically. Wilbanks (1986, table IV) presents race-specific state homicide rates. In every state except Hawaii the black murder rate is a multiple of the white; and the highest state white murder rate is well below the lowest state black murder rate for any state with a sizeable black population.

The Bureau of Justice Statistics compiles data on homicides by race for “local reporting agencies”—basically police departments—that submit information to both the Uniform Crime Reports (UCR) and to the Supplemental Homicide Reports (SHR) that the FBI maintains. This

---

racial differences in means are the same for young men as for old. Since racial mean differences in income, education, and wealth are greater among the old than among the young, and the variance of most variables rises with age, our assumptions of constant mean difference and constant variance were favorable to the tail-of-the-distributions theory. Despite this, the theory is not supported by the evidence.

covers about 100 large jurisdictions, although it does not include New York City and Chicago (U.S. Bureau of Justice Statistics 2009). We estimated murder victimization rates for blacks and non-blacks from this data, the Census, and the American Community Survey by assuming that the racial distribution of UCR murders not reported in the SHR was the same in each agency-year as those reported. We averaged the years 1989-1991 and compared to the 1990 census, the years 1999-2001 and compared to the 2000 census, and the years 2005-2007 and compared to the 2006 American Community Survey. (We did not try to estimate white or non-Hispanic white murder rates because of the difficulties in reporting Hispanic murder victims.) In almost all jurisdictions in almost all years, the black murder victimization rate was greater than the white. All of the jurisdictions with ratios less than one have large Hispanic or Hawaiian populations. Table 6 shows some basic facts about these ratios.

Table 6: Ratios of Black to Non-black Murder Victimization Rates in Large Reporting Jurisdictions

	1989-1991	1999-2001	2005-2007
Total reported	93	87	84
Median ratio	4.25	3.37	4.34
Number > 7	12	9	20
Number < 1	2	5	2

Thus although ratios in individual cities are generally not as high as the national ratios, they are high almost everywhere. Part of the story is that blacks tend to live in places that are more dangerous for whites too, but it is not the whole story. Cubbins et al. (2000) find that age-specific male homicide rates are greatest for both blacks and whites in large metropolitan areas, and least in non-metropolitan and rural areas. They also find that the ratio of black to white homicides follows the same pattern, being greatest in large metropolitan areas and least in rural. Indeed, Cubbins et al. find no significant difference between black and white age-specific male homicide in nonmetropolitan and rural areas. Thus density increases homicide rates for all groups, but increases homicide rates for blacks more than for whites. In our interpretation, greater density reflects more frequent interactions and more scope for disputes.

The rough equivalence of racial homicide rates in rural areas also casts doubt on explanations of the disparity that rely on a “subculture of violence” (e.g., Wolfgang and Ferracuti 1967). If blacks have a subculture of violence and have traditionally lived in rural areas, why shouldn’t the subculture be most strongly manifest in rural areas? Indeed, sociologists have generally rejected the subculture of violence explanation on other grounds (Hawkins 1987, Almgren et al. 1998, Parker 1989, Sampson 1987).

## 2.5 Aggravated Assaults

Like murders, aggravated assaults are violent attacks; by definition, the assailants use weapons or the victims sustain serious injuries, or both. Like murders, they are primarily intraracial (U.S.

Bureau of Justice Statistics, 2009, table 42). A subculture of violence theory would predict that the racial disparity in aggravated assault should resemble the racial disparity in murder. But it does not. In the 2004 National Criminal Victimization Survey blacks were only about 1.7 times as likely as whites to be aggravated assault victims. Nor is the racial disparity greatest among the demographic groups among whom aggravated assault is most prevalent. Indeed, among 20-24 year old men, whites were more likely than blacks to be aggravated assault victims in both 2003 and 2004 (table 10). Aggravated assault was over 65 times as common as murder in 2004. Blacks, especially young men, are not a lot more violent than whites.

It is possible that blacks fail to report actual aggravated assaults in the NCVS more often than whites do. The NCVS Survey Methodology (Bureau of Justice Statistics 2004, p. 6) states: "Research based on interviews of victims obtained from police files indicates that assault is recalled with least accuracy of any crime measured by the NCVS. This may be related to the tendency of victims to not report crimes committed by offenders who are not strangers, especially if they are relatives. In addition, among certain groups, crimes which contain elements of assault could be part of everyday life, and are therefore forgotten or not considered important enough to mention to a survey interviewer." For this reason, we have concentrated on aggravated rather than simple assaults. Aggravated assaults by definition require that the assailant either use a weapon or inflict serious injury.

The NCVS also lets us look at different types of assaults that may be so serious that forgetting them or treating them as part of everyday life would be unlikely. Thus by combining information from tables 5, 77, 79, and 88 of the NCVS for 2004 we can infer that blacks were about twice as likely to be victims of an assault that required them to receive hospital care or incur medical expenses, and about one and a half times as likely to be victims of an assault that required them to lose time from work. All of these ratios are well below the ratio for murder.

## 2.6 Micro-data

Rogers et al (2001) link micro-data from the National Health Survey with the National Death Index to see how sociodemographic variables affect homicide victimization. They calculate the monthly hazard of dying by homicide between 1987 and 1997. Holding only age and sex constant, the black hazard rate was 6.8 times as large as the white. Controlling in addition for marital status, education, employment status, and geography reduced the hazard ratio to 4.5. Thus, holding this rich array of sociodemographic information constant, a black person was 4.5 times as likely to be murdered as a white person. This unexplained gap motivates the analysis developed here.

# 3 The Model

## 3.1 Preliminaries

There are two recognizable social groups, which we identify with subscripts  $b$  and  $w$ . An *interaction* occurs when two individuals (who may or may not belong to the same group) are randomly matched and engage in a dispute. Individuals engaged in the dispute choose one of two actions, violence

( $V$ ) or non-violence ( $N$ ). Choices are made simultaneously. If neither is violent, then neither is hurt and their payoffs are normalized to equal zero. If one is violent and the other is not, there is a probability  $p$  that the latter is killed. If both are violent, there is a probability  $2q$  that one of them is killed, and each of the two is equally likely to be the homicide victim. The likelihood that both are killed is assumed for simplicity to be zero. We assume that

$$q < p < 2q, \tag{1}$$

so an individual faced with a violent opponent is more likely to survive if he himself chooses to be violent. This reflects the peculiar characteristic of murder: killing a violent opponent can prevent one from being killed.<sup>11</sup>

When a homicide occurs, the loss to the victim is  $\delta$ , assumed to be strictly positive and commonly known. The cost to the offender is  $\gamma$ , which is private information and takes into account the likelihood of apprehension, legal penalties, and all opportunity costs. Such costs have an idiosyncratic component, but may also depend on the group identity of both victim and offender. To the extent that killers are pursued more vigorously and punished more severely if the victim is white rather than black, the cost distribution will be sensitive to the identity of the victim. Similarly, the subjective costs of arrest and incarceration depend on one's outside options, such as employment opportunities and accumulated assets, and the marginal penalties for murder depend on whether or not one is already engaged in criminal activities. This would suggest that the cost distributions depend also on the identity of the offender. To allow for such effects, as well as idiosyncratic heterogeneity, let  $F_{ij}(\gamma)$  denote the (commonly known) distribution from which costs are drawn when the offender belongs to group  $i$  and the victim to group  $j$ , where  $i, j \in \{b, w\}$ .

We assume for notational simplicity that all four distributions  $F_{ij}(\gamma)$  have the same support, which we take to be the real line. Hence  $F_{ij}(0) > 0$  for all  $i, j \in \{b, w\}$ , which implies that for all four interaction types, some (possibly small) measure of individuals have costs  $\gamma < 0$  and will therefore choose to be violent during a dispute even if they are interacting with someone known to be non-violent. This follows from the fact that against a nonviolent opponent one's expected payoff is 0 from choosing nonviolence, and  $-p\gamma$  from choosing violence; the latter exceeds the former if  $\gamma < 0$ . Similarly, in all four interaction types, some measure of individuals have costs  $\gamma > \delta$ , and these will be nonviolent even if they are interacting with someone known to be violent. To see this, note that against an opponent known to be violent, the expected payoff when choosing nonviolence is  $-p\delta$ , while the expected payoff when choosing violence is

$$-q\delta - q\gamma < -2q\delta < -p\delta$$

provided that  $\delta < \gamma$ , since  $p < 2q$  from (1).

Since group identities are observable, each type of interaction induces a distinct Bayesian game which we denote  $\Gamma_{ij}$ . Let  $s_{ij} : \mathbf{R} \rightarrow \{V, N\}$  and  $s_{ji} : \mathbf{R} \rightarrow \{V, N\}$  respectively denote strategies for the two players in  $\Gamma_{ij}$ . Any such pair of strategies (together with the corresponding distribution

---

<sup>11</sup>A special case occurs when each individual shoots once, in randomly determined order, and each shot kills with probability  $p$ . If the first shot kills then the second does not occur. In this case  $q = p - p^2/2$  which clearly satisfies (1); see O'Flaherty and Sethi (2010a) for further details.

functions) induces for each player a probability that violence will be chosen. Let  $\lambda_{ij}$  and  $\lambda_{ji}$  respectively denote these probabilities of violence.

### 3.2 Equilibrium

Given any pair of probabilities  $\lambda_{ij}$  and  $\lambda_{ji}$ , the best responses by the two players have the following structure: there exist thresholds  $\tilde{\gamma}_{ij}$  and  $\tilde{\gamma}_{ji}$  such that group  $i$  individuals choose violence if and only if they have  $\gamma < \tilde{\gamma}_{ij}$ , and group  $j$  individuals choose violence if and only if they have  $\gamma < \tilde{\gamma}_{ji}$ .<sup>12</sup> The reason for this is that for any given belief, the payoff from nonviolence is independent of  $\gamma$  while the payoff from violence is strictly decreasing in  $\gamma$ . Since  $\gamma < 0$  individuals always choose violence and  $\gamma > \delta$  individuals never do, the thresholds  $\tilde{\gamma}_{ij}$  and  $\tilde{\gamma}_{ji}$  must each lie in the interval  $[0, \delta]$ . Hence equilibrium strategies have the following structure: there exist a pair of thresholds  $(\tilde{\gamma}_{ij}, \tilde{\gamma}_{ji}) \in [0, \delta]^2$  such the players choose violence if and only if their (privately observed) value of  $\gamma$  lies below the corresponding threshold. The thresholds  $(\tilde{\gamma}_{ij}, \tilde{\gamma}_{ji})$  induce probabilities of violence  $\lambda_{ij}$  and  $\lambda_{ji}$  given by

$$\lambda_{ij} = F_{ij}(\tilde{\gamma}_{ij}), \quad (2)$$

$$\lambda_{ji} = F_{ji}(\tilde{\gamma}_{ji}). \quad (3)$$

Strategies based on the thresholds  $(\tilde{\gamma}_{ij}, \tilde{\gamma}_{ji})$  correspond to an equilibrium if and only if they are best responses to the beliefs  $(\lambda_{ij}, \lambda_{ji})$  that are consistent these strategies.

Consider a candidate equilibrium  $(\tilde{\gamma}_{ij}, \tilde{\gamma}_{ji}) \in [0, \delta]^2$ . Since the threshold individuals must be indifferent between violence and nonviolence, we have

$$\lambda_{ji}p\delta = \lambda_{ji}q(\tilde{\gamma}_{ij} + \delta) + (1 - \lambda_{ji})p\tilde{\gamma}_{ij}$$

and hence

$$\tilde{\gamma}_{ij} = \frac{\lambda_{ji}\delta(p - q)}{\lambda_{ji}q + (1 - \lambda_{ji})p}. \quad (4)$$

Using (3), we therefore obtain

$$\tilde{\gamma}_{ij} = \frac{F_{ji}(\tilde{\gamma}_{ji})\delta(p - q)}{F_{ji}(\tilde{\gamma}_{ji})q + (1 - F_{ji}(\tilde{\gamma}_{ji}))p} \equiv G_{ji}(\tilde{\gamma}_{ji}). \quad (5)$$

Note that  $G_{ji}(\tilde{\gamma}_{ji})$  is strictly increasing and satisfies

$$0 \leq G_{ji}(\tilde{\gamma}_{ji}) \leq \delta \left( \frac{p - q}{q} \right) < \delta,$$

where the last inequality follows from (1). The same reasoning may be applied to the threshold  $\tilde{\gamma}_{ji}$ , to yield

$$\tilde{\gamma}_{ji} = \frac{F_{ij}(\tilde{\gamma}_{ij})\delta(p - q)}{F_{ij}(\tilde{\gamma}_{ij})q + (1 - F_{ij}(\tilde{\gamma}_{ij}))p} \equiv G_{ij}(\tilde{\gamma}_{ij}),$$

---

<sup>12</sup>We adopt the convention that individuals who are indifferent between the two actions (given their beliefs) will choose non-violence. The set of individuals who are indifferent will be of zero measure in any equilibrium, and this convention therefore has no bearing on our results.

where

$$0 \leq G_{ij}(\tilde{\gamma}_{ij}) < \delta. \quad (6)$$

Define the function  $\Lambda : [0, \delta]^2 \rightarrow [0, \delta]^2$  as follows:

$$\Lambda(\tilde{\gamma}_{ij}, \tilde{\gamma}_{ji}) = (G_{ji}(\tilde{\gamma}_{ji}), G_{ij}(\tilde{\gamma}_{ij})).$$

A fixed point of this mapping is a Bayes-Nash equilibrium, and since  $\Lambda$  is continuous and  $[0, \delta]$  is compact, the existence of equilibrium follows immediately from Brouwer's fixed point theorem.

In general, equilibrium will not be unique. The following result establishes sufficient conditions for uniqueness in the case of homogenous interactions, in which both parties to the dispute belong to the same group  $i \in \{b, w\}$ .

**Proposition 1.** *If  $f_{ii}(\tilde{\gamma}_{ii})\delta + 2F_{ii}(\tilde{\gamma}_{ii}) < 2$  at any equilibrium value of  $\tilde{\gamma}_{ii}$ , then  $\Gamma_{ii}$  has a unique equilibrium.*

Since  $\tilde{\gamma}_{ii} < \delta$  and  $F_{ii}(\delta) < 1$ , uniqueness is ensured if the density  $f_{ii}$  is sufficiently low at any equilibrium point. We shall assume throughout that this is indeed the case, and that equilibrium is unique for homogeneous interactions.

Uniqueness conditions for interactions in which the two opponents are drawn from different groups are more complicated and harder to interpret. None of our results require that such interactions are characterized by a unique equilibrium, and we therefore omit these conditions here.

### 3.3 Murder and Victimization Rates

Given an interaction involving individuals drawn from groups  $i$  and  $j$  respectively, let  $m_{ij}$  denote the likelihood that the former will kill the latter. This depends on the probabilities of violence as follows:

$$m_{ij} = \lambda_{ij}(\lambda_{ji}q + (1 - \lambda_{ji})p). \quad (7)$$

Define the function  $\varphi(\lambda)$  as follows:

$$\varphi(\lambda) = \lambda(\lambda q + (1 - \lambda)p),$$

so  $m_{ii} = \varphi(\lambda_{ii})$ . Note that

$$\varphi'(\lambda) = p - 2\lambda p + 2\lambda q > p(1 - \lambda) \geq 0$$

since  $2q > p$  from (1) and  $\lambda \geq 0$ . Hence  $\varphi(\lambda)$  is strictly increasing and maps  $[0, 1]$  to  $[0, q]$ . Furthermore,  $\varphi''(\lambda) = -2(p - q) < 0$ , so  $m_{ww}$  is more sensitive to an increase in  $\lambda_{ww}$  than  $m_{bb}$  is to an equal increase in  $\lambda_{bb}$ . The intuition for this is as follows: in a group with initially lower rates of violence, increased violence results in greater killing because violent individuals are more likely to be matched with non-violent ones, meaning that they kill with greater probability.

Next consider the likelihood of victimization. Given an interaction involving individuals drawn from groups  $i$  and  $j$  respectively, let  $v_{ij}$  denote the likelihood that the former will be killed by the latter. This is given by

$$v_{ij} = \lambda_{ji}(\lambda_{ij}q + (1 - \lambda_{ij})p). \quad (8)$$

For within group interactions,  $v_{ii} = m_{ii}$ . For interactions involving members of different groups, however, victimization and murder rates will differ in general.

The rates  $m_{ij}$  and  $v_{ij}$  defined here are conditional on the occurrence of an interaction between someone from group  $i$  and one from group  $j$ , and are independent of the frequencies with which different types of dyadic interaction arise. Measured rates of murder and victimization will, of course, depend on these frequencies, which in turn depend on the demographic composition of the population, as well as the extent of segregation in social interactions.

### 3.4 Segregation

In order to explore the relationship between the structure of social interaction and the incidence of homicide within and between groups, we use a simple model of segregation adapted from Chaudhuri and Sethi (2008). Let  $\beta$  denote the share of blacks in the total population. Given any individual, let  $\eta$  denote the probability that his opponent is drawn exclusively from his own group, and let  $1 - \eta$  denote the probability that the opponent is drawn randomly from the population at large (and hence could belong to either group). The case  $\eta = 0$  corresponds to purely random matching, while  $\eta = 1$  corresponds to complete segregation, with no interaction across groups.

For a black individual, the likelihood that his opponent is also black is  $\eta + (1 - \eta)\beta$ , while the likelihood that his opponent is white is  $(1 - \eta)(1 - \beta)$ . Similarly, for a white individual, the likelihood that his opponent is also white is  $\eta + (1 - \eta)(1 - \beta)$ , while the likelihood that his opponent is black is  $(1 - \eta)\beta$ . The per-capita murder rates for blacks and whites respectively are then defined as follows:

$$m_b = (\eta + (1 - \eta)\beta)m_{bb} + (1 - \eta)(1 - \beta)m_{bw}, \quad (9)$$

$$m_w = (\eta + (1 - \eta)(1 - \beta))m_{ww} + (1 - \eta)\beta m_{wb}. \quad (10)$$

Similarly, the per-capita murder victimization rates for blacks and whites respectively are given by:

$$v_b = (\eta + (1 - \eta)\beta)v_{bb} + (1 - \eta)(1 - \beta)v_{bw}, \quad (11)$$

$$v_w = (\eta + (1 - \eta)(1 - \beta))v_{ww} + (1 - \eta)\beta v_{wb}. \quad (12)$$

Given these definitions, we now explore the manner in which identity contingent costs of murder affect the incidence of violence in various dyadic interactions, and the effects of segregation and demographic structure on murder and victimization rates.

## 4 Identity Contingent Costs of Killing

There are several reasons why the costs of killing may depend on the racial identity of either the victim or the offender (or both). It would be difficult to maintain that laws are enforced uniformly across neighborhoods and across racial groups, and there is evidence to suggest that victim characteristics affect the vigor with which offenders are pursued and prosecuted, and the harshness of the sentences that they face. Glaeser and Sacerdote (2000) find that expected punishment is significantly reduced for many crimes, including homicide, when the victim is black, holding many other

circumstances constant. In addition, people whose death will not upset a jury greatly (drug dealers, career criminals, or unemployed vagrants, for instance) have more to fear from any encounter, since their deaths are not likely to be punished as harshly. To the extent that such characteristics are over-represented among African-Americans, they face greater danger from potential offenders. Accordingly, we assume that for each  $i \in \{b, w\}$

$$F_{ib}(\gamma) \geq F_{iw}(\gamma). \tag{13}$$

Note that (13) is consistent with equality in costs across victim groups, but rules out the possibility that it is strictly more costly to kill when the victim is black rather than white.

Similarly, offender characteristics can affect the costs of committing murder, for a wide variety of reasons. First, individuals with low incomes or poor employment prospects have less to lose from incarceration, and to the extent that these characteristics differ by race, so will the cost distributions. Racial disparities in income distributions, unemployment rates and socioeconomic status are well documented. Second, blacks are overrepresented relative to their population share in certain categories of illegal business, especially anonymous vice crimes such as drug selling, which are highly concentrated in segregated areas of central cities.<sup>13</sup> People who work in illegal markets, particularly markets for anonymous vice, have many reasons to be violent. As Miron (1999) has emphasized, legal means of contract enforcement and dispute resolution are not available to these businesses, and so willingness and ability to use violence are required for success. Markets are imperfect and so deaths of particular individuals can present large and persistent profit opportunities. Cooperation with law enforcement can be very harmful to these businesses, so assassination of suspected informants is routinely used as a business tool. And the marginal penalty for murder is lower for people in this business: if you have a high probability of getting a stiff sentence for drug dealing in the near future, the prospect of getting an additional sentence for murder is less daunting.<sup>14</sup> Finally, blacks are heavily overrepresented in the prison population, which can plausibly be assumed to result in greater fear of incarceration among some whites.

These considerations suggest that the marginal penalties for murder, and hence the costs of committing homicide, are greater for whites. On the other hand, holding constant the identity of the victim, the criminal justice system has historically been more punitive towards black offenders.<sup>15</sup>

---

<sup>13</sup>We have discussed reasons for this concentration elsewhere (see O’Flaherty and Sethi, 2010b). Vice crimes are geographically concentrated in central cities because they involve scale independent costs of protection, giving rise to increasing returns. They also cause demographic shifts in the surrounding population, inducing more affluent households as well as lower income whites to exit. Participation in such activities as well as exposure to them reflects local demographic characteristics, with significant black overrepresentation.

<sup>14</sup>Another crime in which blacks are heavily overrepresented is robbery. In O’Flaherty and Sethi (2008) we argue that this is due in part to the fact that racial stereotypes condition the behavior of robbery victims. Victims are more fearful of robbers who come from groups who are on average poorer and more desperate; they resist blacks less often because they expect that such resistance is likely to be met with violent attempts to force compliance. As a result, potential robbers from stereotyped groups meet with less resistance and find this crime to be more lucrative and less risky. This has consequences for racial disparities in murder. Most directly, sometimes robberies go awry and become murders; most felony murders are in this category. Furthermore, people who are potential robbers often find it to their advantage to be armed, either with weapons or with a nasty temper; in either case the marginal penalties for committing murder are lower. Stereotypes can also account for greater black involvement in anonymous vice: being perceived to be violent is an advantage not only for robbers but also for pimps and drug dealers.

<sup>15</sup>Glaeser and Sacerdote (2000) identify this effect, but find it to be small and not statistically significant.

We assume here that the effects of racial income disparities and occupational structure on marginal penalties for murder are not outweighed by any possible leniency shown to white offenders in the judicial system. In this case, for each  $j \in \{b, w\}$ ,

$$F_{bj}(\gamma) \geq F_{wj}(\gamma). \quad (14)$$

This allows for the possibility of equal distributions of marginal penalties, but rules out the case in which marginal penalties for homicide are strictly smaller for whites.

We shall assume that both (13) and (14) hold. In addition, if (13) holds with strict inequality, we say that the costs of committing murder are contingent on victim identity, or *victim contingent*. Similarly, if (14) holds with strict inequality, we say that the costs of committing murder are *offender contingent*. Costs may be both victim and offender contingent, although these hypotheses have somewhat different implications and we explore them independently.

Consider first the case in which the costs distributions are contingent on the identity of the victim but not on that of the offender. This reflects the hypothesis that murders with black victims are less likely to be solved than those with white victims. Under such conditions one would expect greater equilibrium violence against blacks than against whites, and this is indeed the case. Less obviously, holding constant the identity of the victim (and hence the cost distributions), blacks are more likely to engage in violence than whites:

**Proposition 2.** *If costs are victim contingent but not offender contingent then  $\lambda_{ww} < \lambda_{bw} < \lambda_{wb} < \lambda_{bb}$  and  $v_b > v_w$  in any equilibrium. An increase in  $\eta$  raises  $m_b$  and lowers  $m_w$ , while an increase in  $\beta$  raises both  $m_b$  and  $m_w$ .*

The group that is victimized more heavily also engages more frequently in violence, because violence plays a *defensive* as well as offensive role. If one is more likely to be killed in a dispute, the incentives to kill preemptively are correspondingly greater. Not surprisingly, since the costs of killing blacks are lower than those for killing whites, blacks are victimized at higher rates in any equilibrium.

Proposition 2 implies that black-on-black disputes are more likely to result in murder than any other dyadic interaction, while white-on-white disputes are least likely to do so. It is important to note, however, that the result does *not* imply a complete ordering of murder rates  $m_{ij}$ . All that can be said is that

$$\max\{m_{ww}, m_{bw}\} < \min\{m_{wb}, m_{bb}\}.$$

For instance, it is entirely possible that  $m_{bb} < m_{wb}$ , in which case blacks face greater danger from whites than from other blacks. To see this, suppose that  $\lambda_{wb}$  (and hence also  $\lambda_{bb}$ ) are close to 1 while  $\lambda_{bw}$  is close to 0. (This will happen if the costs of killing whites are much greater than the costs of killing blacks.) Then, using (7),  $m_{bb}$  will be approximately equal to  $q$  while  $m_{wb}$  will be approximately equal to  $p > q$ . In this case blacks refrain from violence in interactions with whites and hence face a greater risk of death than they would if they were interacting with someone black. For this reason, segregation has ambiguous effects on black victimization rates: blacks face greater violence in their interactions but also act preemptively to protect themselves more often. The conditions under which such effects arise have prevailed through extended periods of US history, when the prosecution of whites for the killing of blacks was practically unheard of.

Since the identity-contingent murder rates  $m_{ij}$  cannot be ranked, neither can the aggregate murder rates  $m_b$  and  $m_w$  for each group. Despite this, one obtains unambiguous comparative statics results for the effects of changes in segregation and population composition. Segregation increases black murder rates and lowers those of whites, while an increased population share of blacks raises murder rates in both groups.

Turning to the case of offender contingent costs, one obtains the following:

**Proposition 3.** *If costs are offender contingent but not victim contingent, then  $\lambda_{ww} < \lambda_{wb} < \lambda_{bw} < \lambda_{bb}$  and  $m_b > m_w$  in any equilibrium. An increase in  $\eta$  raises  $v_b$  and lowers  $v_w$ , while an increase in  $\beta$  raises both  $v_b$  and  $v_w$ .*

As in the case of victim contingent costs, violence is greatest in all black interactions and least in all-white interactions. However, in this case the logic is somewhat different: the group with lower marginal penalties for killing faces greater (preemptive) violence in all interactions. Furthermore,  $\lambda_{wb} < \lambda_{bw}$  in the case of offender contingent costs, while the opposite is the case with victim contingent costs. With offender contingent costs one can rank aggregate murder rates but not aggregate victimization rates. All that can be shown is that

$$\max\{v_{ww}, v_{bw}\} < \min\{v_{wb}, v_{bb}\},$$

which is consistent with the possibility that  $v_{wb} > v_{bb}$ . Whites could, in principle, be victimized at higher rates even though they face less violence in all interactions, provided that are sufficiently reluctant to use preemptive force. Nevertheless, we see that greater segregation results in greater black victimization and lower white victimization, while a shift towards blacks in demographic composition raises both victimization rates.

What if costs are both victim contingent and offender contingent? In this case, it can be shown that

$$\lambda_{ww} < \min\{\lambda_{wb}, \lambda_{bw}\} \leq \max\{\lambda_{wb}, \lambda_{bw}\} < \lambda_{bb}$$

Hence the greater incidence of violence in black-on-black interactions relative to white-on-white interactions can be accounted for by either victim contingent costs or offender contingent costs, or any combination of the two. Putting Propositions 2-3 together, the model suggests that greater segregation raises both murder rates and victimization rates among blacks but lowers them among whites, and a larger black share in the population raises both murder and victimization rates in both groups.

Since segregation levels and demographic structure are measurable with fairly high accuracy, the model yields testable predictions regarding cross-sectional variation in murder rates across metropolitan areas. In particular, the parameter  $\eta$  can be inferred from published data on the index of isolation: in terms of our model, blacks and whites have isolation indexes equaling  $\eta + (1 - \eta)\beta$  and  $\eta + (1 - \eta)(1 - \beta)$  respectively. Holding constant the population composition, therefore, greater black isolation should correspond to higher murder rates among blacks and lower rates among whites. This is consistent with the empirical findings of Shihadeh and Flynn (1996), who identify a strong positive and significant relationship between the index of black isolation and black murder arrest rates. A one-standard deviation increase in isolation raises murder arrest by half a standard

deviation. Shihadeh and Flynn also find that black population share and the index of dissimilarity are positively related to murder in an equation without the index of isolation, which again is consistent with our predictions. They do not, however, examine the effects of black isolation and the population composition on *white* murder arrests; our model suggests that these effects are systematic and worth exploring.

Weiner et al. (2009) provide some empirical support for the prediction that integration reduces the black homicide rate, but does not provide a clean test of this proposition. They study court-ordered school desegregation and find that implementation of these court orders reduces black youth homicide victimization by around 25 percent. Desegregation could be acting in two different ways in our model: it could increase the proportion of matches that are inter-racial (the “racial mixing effect”) or it could improve the human capital and psychological well-being of black students and thus shift the distribution of  $\gamma$  away from murder (the “black enrichment effect”). Both effects reduce the black homicide victimization rate. Thus while the results of Weiner et al. provide general support for the model in this paper, they do not find a significant racial mixing effect.

Guryan (2004) found that school desegregation caused large reductions in black drop-out rates, and so there is at least indirect support for the existence of a black enrichment effect. Weiner et al. also provide more direct evidence. Adult black homicide offending and victimization fell; our model predicts that this will follow from the black enrichment effect if black youths and black adults match with each other frequently. Decades later, black adults who as youths attended desegregated schools are significantly less likely to be arrested for homicide than similarly aged black adults who attended segregated schools; the long-lasting black enrichment effect could cause this reduction but the short-lived racial mixing effect could not. Black youth victimization fell in the summer, when little change in racial mixing could be expected, almost as much as it did during the school year. White youth homicide victimization did not rise, and statistically insignificant results suggest it fell. Combining Guryan’s estimate of the effect of school desegregation on dropping out with Lochner and Moretti’s (2004) estimates of the effect of high school completion on homicide rates yields predicted reductions in black homicide that are a large fraction of the actual reductions.

## 5 Extensions of the basic model

While the basic model identifies some key mechanisms that help us understand the inter-racial murder gap and the effects of segregation, it has two shortcomings.

The first problem is magnitude: the basic model produces a black murder rate six times the white murder rate only if differences in fundamentals are considerable—perhaps implausibly large. To get a sense of the magnitudes involved, consider a version of the model in which the distributions of  $\gamma$  within each group are normal with unit variance and means  $\mu_b$  and  $\mu_w$  respectively. For simplicity, assume that racial segregation is complete; allowing for some integration would merely cause black and white murder rates to come closer together. Let  $\lambda_i$  denote the probability that an individual belonging to group  $i$  will use violence, and let  $\tilde{\gamma}_i$  denote the type in group  $i$  who is indifferent between violence and non-violence. Since costs are normally distributed with unit variance and all disputes are intraracial,  $\lambda_i = \Phi(\tilde{\gamma}_i - \mu_i)$ , where  $\Phi$  is the distribution function for the standard

normal. From (4), we therefore have

$$\tilde{\gamma}_i = \frac{\lambda_i \delta (p - q)}{p - \lambda_i (p - q)} = \frac{\Phi(\tilde{\gamma}_i - \mu_i) \delta (p - q)}{p - \Phi(\tilde{\gamma}_i - \mu_i) (p - q)}.$$

Now suppose that  $\mu_b = 1.8$ , which implies that about 3.6% of blacks would use violence even in the absence of a preemptive motive. Assume the following specification of parameter values:

$$\delta = 25, \quad p = 0.10, \quad q = 0.08. \quad (15)$$

In this case  $\tilde{\gamma}_b = 0.453$ ,  $\lambda_b = 0.089$ , and the murder rate is  $m_b = 0.009$ . We may now ask what the distribution of costs among whites must be in order that the ratio of murder rates is approximately six to one. Solving this yields  $\mu_w = 2.25$ , which implies  $\tilde{\gamma}_w = 0.074$ ,  $\lambda_w = 0.015$ , and  $m_w = 0.0015$ . Note that with this cost distribution, the proportion of whites who would use violence even in the absence of a preemptive motive is  $\Phi(-2.25) = 0.012$ . In other words, the proportion of blacks who would murder in the absence of a preemptive motive (3.6 percent) must be three times as great as the proportion of whites (1.2 percent) who would murder in the absence of preemption. Furthermore, this underestimates the degree of difference in fundamentals necessary to generate plausible disparities in murder rates, since these calculations have assumed that segregation is complete. While this example entails a very rough calibration, it does suggest that the basic model relies on too great a difference in fundamentals in order to generate an empirically relevant range of racial disparities in murder rates.

The more serious problem for the basic model is that it requires that for intraracial disputes—which means the vast majority of disputes—the thresholds  $\tilde{\gamma}_i$  between violence and non-violence be the same for all age-gender (or other) subgroups. From the likelihood ratio proposition (see Section 2.2), this implies that the black-white murder ratio will be higher for age-gender groups with lower absolute murder rates, which is the opposite of what we observe. To see why, consider two age groups (young, old) within each of the two social groups (black, white). Suppose  $\gamma$  is normally distributed with unit variance in all four subgroups. Let  $y$  and  $o$  denote the means of these distributions for young and old blacks respectively, and let  $y + w$  and  $o + w$  denote the corresponding distributions for whites, where  $w > 1$  and  $o > y$ . As before,  $\tilde{\gamma}_i$ ,  $i \in \{b, w\}$ , denote the value of  $\gamma$  at which an individual belonging to group  $i$  is indifferent between violence and non-violence. Since the murder rate for young black men is greater than that for young white men,  $\Phi(\tilde{\gamma}_b - y) > \Phi(\tilde{\gamma}_w - y - w)$ , which implies

$$\tilde{\gamma}_b - \tilde{\gamma}_w + w > 0. \quad (16)$$

Now write the black-white murder ratios among young and old as

$$R_y = \frac{\Phi(\tilde{\gamma}_b - y)}{\Phi(\tilde{\gamma}_w - y - w)} = \frac{\Phi(X_y + q)}{\Phi(X_y)}$$

and

$$R_o = \frac{\Phi(\tilde{\gamma}_b - o)}{\Phi(\tilde{\gamma}_w - o - w)} = \frac{\Phi(X_o + q)}{\Phi(X_o)},$$

where  $q = \tilde{\gamma}_b - \tilde{\gamma}_w + w > 0$  from (16) and, for each  $k \in \{y, o\}$ ,

$$X_k = \tilde{\gamma}_w - k - w.$$

Since  $X_o < X_y$ , the likelihood ratio proposition implies  $R_o > R_y$ , contrary to what we observe.

In order to address these shortcomings, we now consider two extensions of the basic model. First, we allow for visible heterogeneity and assortative matching *within* social groups. For instance, suppose that within each group, individuals engaged in risky illegal activities (such as drug selling or robbery) are more likely to interact with each other than with individuals outside this occupational category. Since such individuals face smaller marginal penalties for murder, the risk of escalation and violence in disputes between them will be extremely high. Furthermore, to the extent that their occupational choices are visible, they will be feared and killed preemptively at greater rates even in interactions with those in other occupational categories. Hence differences across groups in the distribution of marginal penalties will result in greater interracial disparities in murder rates than our baseline model would suggest. Even those with high marginal penalties for murder will kill at greater rates if they belong to a social group in which those with low marginal penalties are encountered more frequently.

The second extension allows for costly investments in lethality (such as firearms or a hair-trigger temper) *before* the interaction stage. The investment decision must be made based on the distribution of types one expects to encounter, so those who are more likely to meet individuals with low marginal penalties for murder will also be more inclined to make investments in lethality. This in turn makes it more likely that disputes will end in murder. Investments by some also beget investments by others, and so small differences in fundamentals once again can get amplified, resulting in large interracial disparities in murder and victimization rates.

## 5.1 The Occupational Model

Our first attempt to alleviate the weaknesses of the basic model is to allow for two occupational subgroups within each social group. For simplicity, we continue to assume complete racial segregation in social interactions. We call one group “vice workers”—people who work in the vice business—and the other group “non-vice workers”—people who don’t. We assume that the difference is visible and easily recognized. We use these labels because of the sharp difference in murder rates that vice employment makes. The composition and size of each subgroup is considered exogenous here; for an account of racial differences in involvement in street vice see (O’Flaherty and Sethi, 2010b).

Our distinction between vice and non-vice workers is similar to Anderson’s (1990) distinction between “street” and “decent” people. We want, however, to categorize people by their activities and associations, which are observable, rather than their values, which are not. Following Venkatesh (2006), moreover, we will emphasize the extent to which the two groups interact.

We assume that within each social group the distribution of  $\gamma$  for non-vice workers stochastically dominates the distribution for vice workers. We also assume that the proportion of vice workers is higher in the black population. Formally, the games with two visible occupational groups within each social group are the same as the game with two visible social groups, which we analyzed in sections 3 and 4, and so all the results about the existence of equilibrium and direction of differences carry over.

For each social group  $i \in \{b, w\}$ , let  $\pi_i$  denote the proportion of vice workers, and let  $\varepsilon$  denote the segregation parameter between vice and non-vice workers (assumed to be the same among

both blacks and whites). Let  $\sigma_{ijk}$  denote the probability that a worker in occupation  $j \in \{v, n\}$  meets a worker in occupation  $k$ , given that they both belong to social group  $i$ . These interaction probabilities can be expressed using matrices  $S_i$  defined as follows:

$$S_i = \begin{bmatrix} \sigma_{ivv} & \sigma_{ivn} \\ \sigma_{inv} & \sigma_{inn} \end{bmatrix} = \begin{bmatrix} \varepsilon + (1 - \varepsilon) \pi_i & (1 - \varepsilon) (1 - \pi_i) \\ (1 - \varepsilon) \pi_i & \varepsilon + (1 - \varepsilon) (1 - \pi_i) \end{bmatrix}$$

To build intuition, first assume that  $\varepsilon = 0$ ; encounters within a social group are totally random. Also assume that  $\pi_b = 3\pi_w$ : vice is three times as common among blacks as among whites. Then encounters between two vice workers are nine times as common among blacks as among whites. If murders occur only in encounters between two vice workers, then the black murder rate will be nine times the white murder rate—clearly above the observed ratio. Of course, encounters are not completely random and murders are not absolutely concentrated in encounters between two vice workers. (If occupational segregation is complete, then encounters between a pair of vice workers are only three times as likely in the black population as in the white.) The question is how much relaxing these extreme assumptions reduces the ratio.

For an example, let  $\pi_b = 0.3$  and  $\pi_w = 0.1$ , with other parameter values given by (15) as before. For vice workers, let  $\gamma \sim N(1.2, 1)$  and for non-vice workers, let  $\gamma \sim N(3.6, 1)$ . Then the probability of violence will be negligible when both parties to a dispute are non-vice workers. It can also be shown that in a meeting between a vice worker and a non-vice worker, the latter will choose violence with very low probability, so preemption will not play much of a role in the actions of the former. The likelihood of violence by the vice worker in this case will be approximately  $\lambda_{vn} = 0.12$ . Disputes between two vice workers will almost always involve violence, with  $\lambda_{vv} \approx 1$ . This might be called a pure occupational model, as the only difference between blacks and whites is the proportion of vice workers; given occupation, characteristics are independent of race—although behavior is not.

Given the rates of violence  $\lambda_{jk}$  that arise when an individual in occupation  $j$  meets one in occupation  $k$ , we can compute the resulting probability  $m_{jk}$  that the former will be killed. Let  $M$  denote the matrix of murder rates, defined as follows:

$$M = \begin{bmatrix} m_{vv} & m_{vn} \\ m_{nv} & m_{nn} \end{bmatrix} = \begin{bmatrix} \lambda_{vv} (q\lambda_{vv} + p(1 - \lambda_{vv})) & \lambda_{vn} (q\lambda_{nv} + p(1 - \lambda_{nv})) \\ \lambda_{vn} (q\lambda_{nv} + p(1 - \lambda_{nv})) & \lambda_{nn} (q\lambda_{nn} + p(1 - \lambda_{nn})) \end{bmatrix}$$

In the example,  $m_{vv} = 0.08$ ,  $m_{nv} = 0.01$ , and all other murder rates are negligible. Given this, the murder rates within each social group  $i$  can be determined, based on the structure of interactions  $S_i$ . Specifically,

$$m_i = \pi_i (\sigma_{ivv} m_{vv} + \sigma_{ivn} m_{vn}) + (1 - \pi_i) (\sigma_{inv} m_{nv} + \sigma_{inn} m_{nn}).$$

First, let  $\varepsilon = 0$ , so that meetings are random within each social group. Then the murder rates are  $m_b = 0.0097$  and  $m_w = 0.0019$  for blacks and whites respectively, a ratio somewhat higher than five to one. This is not far from the empirical ratio. In the absence of preemption, blacks would commit three times as many murders as whites.<sup>16</sup>

<sup>16</sup>It can be verified that aggregating distributions of  $\gamma$  across occupational subgroups, about 3.5% of blacks and about 1.2% of whites have  $\gamma < 0$ ; these are the individuals who would choose violence even in the absence of a preemptive motive.

There are two problems with this example, however. First, it implies that the black-white murder victimization ratio is the same for non-vice workers as for vice workers: whatever their occupation, blacks are three times as likely as whites (with the same occupation) to meet vice workers and get killed. Second it relies on an implausibly low value of  $\varepsilon$ . People do not meet completely randomly within race. Suppose that  $\varepsilon = 0.2$ . Then the black murder rate is 12.5 per thousand and the white murder rate is 3.1 per thousand—a four to one ratio.

Moreover, black non-vice workers remain three times as likely as white to meet vice workers, and so their murder victimization ratio remains three times as high, but black vice workers are now only 1.57 times as likely to meet other vice workers as their white counterparts (black vice workers meet vice workers 44 percent of the time; white vice workers meet vice workers 28% of the time). Thus for  $\varepsilon > 0$ , the pure occupational model does not accurately predict the pattern of inter-racial murder ratios; to do this we need to consider preemptive investments in lethality.

## 5.2 The Investment Model

In the interactions discussed so far, agents make decisions only after the racial identity and occupation of their partners has been revealed. Sometimes, however, decisions have to be made earlier. For instance, if one wants to obtain a gun, waiting until after a dispute has begun may be too late. Similarly, developing a hair-trigger temper or skill with using weapons are things that people usually do without any particular dispute in mind. They are investments made before the partner is known. People who are more likely to encounter violent partners have more to gain from investing like this, and after they have invested they are more likely to be violent. Violence begets violence, and so the possibility of investment is another channel through which racial disparities in fundamentals can be exacerbated.

Investment comes into play most strikingly in the occupational model. As long as  $\varepsilon < 1$ , black vice workers are more likely to meet violent partners than white vice workers are, and so are more likely to invest; hence they are more likely to be violent. So the black murder rate for vice workers is higher than the white murder rate for vice workers for three reasons: because they are more likely to meet violent people, because they are more likely to invest, and because they are more likely to meet people who have invested.

Specifically, let investment work as follows. Each vice worker must decide whether or not to invest (a binary decision), before his or her partner is known. (We assume that non-vice workers do not have access to the investment technology; even if they did their rates of investment would be negligible). Investment costs a positive amount payable immediately; not investing costs nothing. For a player who has invested, the cost of violence is reduced by some fixed amount whenever violence is used (even if the partner is not killed). No change in payoffs occurs for a player who has not invested.

For a specific example, let all parameters and distributional specifications be the same as in the occupation model. This example is non-racial: the only difference between blacks and whites is that blacks are more likely to be employed in vice. Recall that under the presumed occupational distribution and interaction structure, black vice workers meet other vice workers 44% of the time, while white vice workers meet other vice workers 28% of the time. Because of this disparity, there

exists a range of values for the costs and benefits of making investments such that those vice workers who intend to use violence only in confrontations with other vice workers will choose to invest if they are black but not if they are white.

Black vice workers invest more because they are more likely to meet vice workers, and people who have invested. As a result, encounters between two vice workers are different for whites than for blacks. For whites, the marginal violent person has not invested, so the possibility of investment makes no difference to this particular type of encounter. For black vice workers, by contrast, the marginal violent person has invested. In fact, all investors and only investors are violent. What is the impact on murder rates? Relative to the occupational model with no investment, white murder rates rise slightly but black murder rates rise substantially. The rise in black murder rates occurs because investments lower the threshold for violence: some who did not previously use violence in any interactions start to do so in interactions with vice workers, and some who previously used violence only in interactions with vice workers are now violent in all interactions. Thus with investment we are able to explain the stylized facts with appeal only to occupation. Adding purely racial differences would increase the disparity; allowing inter-racial meetings would decrease it.

Investment implies that your exposure to violent people in the past affects your reaction to people today—and other people’s reactions to you today too. One-time interventions can have lasting effects. Thus investment offers a third possible explanation for the effects of school desegregation that Weiner et al. found. Suppose school desegregation reduces the exposure of black youths to violent classmates, and so reduces their investment in long-lived homicidal technology, like explosive tempers. Going forward, this reduction in investment looks much like the black enrichment effect. It produces contemporaneous decreases in black adult homicide, long-lasting decreases in homicide by the cohort in question, year-round reductions in homicide, and future reductions in white homicide if post-school inter-racial matching probabilities stay the same. (Weiner et al. found a statistically significant reduction in white 15-24 year old homicide victimization beginning five years after desegregation was ordered.)

## 6 Conclusions

The key idea explored in this paper is that murder can be a preemptive act that is driven by the fear of being killed. When the subjective costs of killing are unobservable at the individual level, racial stereotypes can influence behavior in such a manner as to cause systematic variations in murder rates across different types of dyadic interaction. Individuals belonging to groups perceived to have low marginal penalties for killing will be feared, and they will accordingly also be killed with greater frequency. By the same token, individuals whose own deaths are less likely to be investigated and prosecuted vigorously will fear being killed, and may therefore be induced to kill preemptively. This means that social groups with high victimization rates will also have high murder rates, even if there is no racial segregation in social interactions. In addition, the model yields clear predictions regarding cross sectional variation: holding constant the population composition, more segregated cities should have the greatest racial disparities in murder rates, while cities with larger black populations should have higher murder rates among both blacks and whites.

In a sense our analysis turns the standard model of offender-victim interaction (Cook 1986) on its head. That model applies well to most index crime: when an exogenous shock like reduced policing makes burglary, for instance, more attractive to potential offenders, the added precautions that potential victims take (purchasing home security systems, for instance) work in the opposite direction to the offender effect, and so the equilibrium change in burglary is smaller than the change that would have occurred if potential victims had not reacted. Victim reaction dampens the system response. But with murder, victim reaction *amplifies* the system response.

While the mechanisms identified here are important, they are only part of the story. A more complete theory must also explain the time series—why black and white murder rates have converged since 1940, and why the ratio has relatively stable over the last two decades. Part of the long-term convergence in murder is probably due to inter-racial convergence in poverty and educational attainment, as our model predicts. But understanding such a long time series also requires us to think about health and medical care. If whites had substantially better access to emergency medical care in the 1930s, then whites would survive some of the kinds of attacks that would have killed blacks; blacks would also be more likely to die from attacks that whites would survive if they were less healthy and more poorly nourished. Behavior, though, responds to changes in medical care and health and so more theoretical work is needed before we can say how changes in these variables should have affected equilibrium murder rates. On one hand, better medical care, *ceteris paribus*, reduces the demand for preemption and so should reduce the number of murders even more than a clinical accounting would suggest. On the other hand, assailants may respond to better medical care by choosing more lethal weapons—guns instead of knives, for instance—or making greater efforts to kill—shooting many times, or at close range, for instance. A long run history of murder must describe not only a contest between medical and weapons technology (which may play out differently in the black community from the white), but also the strategic responses this contest engenders.

Over a horizon of two or three decades, the relative stability of the inter-racial murder ratio is another phenomenon that needs more study. First differences in black and white national murders are correlated and so it appears that blacks and whites nationally are subject to common shocks. But individual city murder rates are quite volatile. In O’Flaherty and Sethi (2010a) we documented parts of this volatility and showed how strategic complementarity contributed to it. The law of large numbers would reconcile city-level volatility with nationwide stability if city murder rates moved independently. Do they? What are local shocks like? The most likely candidate story about local shocks is that they arise from changes in law enforcement—either changes in the policing of homicides or changes in vice laws and their enforcement. Considerable empirical literature links both kinds of law enforcement changes to changes in homicide. Ultimately, then, understanding the dynamics of the racial murder gap may require understanding the political economy of law enforcement decisions and of the public’s tolerance of extraordinarily high murder rates.

## Appendix

**Proof of the Likelihood Ratio Proposition.** By algebra,

$$R(x) = \frac{\int_{-\infty}^{x+\mu} \phi(t) dt}{\int_{-\infty}^x \phi(t) dt} = \frac{\int_{-\infty}^x \phi(t+\mu) dt}{\int_{-\infty}^x \phi(t) dt} = \int_{-\infty}^x L(t) w(t) dt,$$

where

$$\int_{-\infty}^x w(t) dt = 1$$

and  $w(t) > 0$  for all  $t$ . Since  $R(x)$  is a weighted average of  $L(t)$ ,  $t \leq x$ , and  $L(t)$  is increasing,

$$L(x) > R(x)$$

for all  $x$ . Thus

$$R(x) = \frac{\phi(x)}{\Phi(x)} (L(x) - R(x)) > 0.$$

Hence  $R(x)$  is increasing in  $x$ . Similarly  $\lim_{x \rightarrow -\infty} R(x) \leq \lim_{x \rightarrow -\infty} L(x)$ , so if  $\lim_{x \rightarrow -\infty} L(x) = -\infty$  then  $\lim_{x \rightarrow -\infty} R(x) = -\infty$ . ■

**Proof of Proposition 1.** From (5), we have

$$\tilde{\gamma}_{ii} = \frac{F_{ii}(\tilde{\gamma}_{ii}) \delta(p-q)}{F_{ii}(\tilde{\gamma}_{ii})q + (1 - F_{ii}(\tilde{\gamma}_{ii}))p} = G'_{ii}(\tilde{\gamma}_{ii}).$$

There will be a unique solution to the this equation provided that  $G'_{ii}(\tilde{\gamma}_{ii}) < 1$  at each equilibrium value of  $\tilde{\gamma}_{ii}$ . A sufficient condition for uniqueness is therefore

$$\frac{(F_{ii}q + (1 - F_{ii})p) f_{ii} \delta(p-q) - F_{ii} \delta(p-q) (f_{ii}q - f_{ii}p)}{(F_{ii}q + (1 - F_{ii})p)^2} < 1.$$

This holds if and only if

$$\begin{aligned} (p-q) f_{ii} \delta p &< (F_{ii}q + (1 - F_{ii})p)^2 \\ &= (p - F_{ii}(p-q))^2 \\ &= p^2 - 2pF_{ii}(p-q) + F_{ii}(p-q)^2 \\ &= p^2 - F_{ii}(p-q)(p+q) \end{aligned}$$

and hence  $G'_{ii}(\tilde{\gamma}_{ii}) < 1$  if and only if

$$f_{ii} \delta p + F_{ii}(p+q) < \frac{p^2}{p-q}.$$

Since  $q < p < 2q$ , the right side of this inequality is greater than  $2p$  and the left side is smaller than  $f_{ii} \delta p + 2pF_{ii}$ . Hence a sufficient condition for uniqueness in the case of homogeneous interactions is

$$f_{ii}(\tilde{\gamma}_{ii})\delta + 2F_{ii}(\tilde{\gamma}_{ii}) < 2 \tag{17}$$

at any equilibrium value of  $\tilde{\gamma}_{ii}$ . ■

**Proof of Proposition 2.** First we show that  $\lambda_{bw} < \lambda_{wb}$ . Suppose not, so  $\lambda_{wb} \leq \lambda_{bw}$ . Note from (4) that  $\tilde{\gamma}_{ij}$  is increasing in  $\lambda_{ji}$ , so  $\tilde{\gamma}_{bw} \leq \tilde{\gamma}_{wb}$ . This, together with the monotonicity of the distribution function  $F_{bw}$  and the fact that (13) holds strictly implies

$$F_{bw}(\tilde{\gamma}_{bw}) \leq F_{bw}(\tilde{\gamma}_{wb}) < F_{wb}(\tilde{\gamma}_{wb})$$

and hence  $\lambda_{bw} < \lambda_{wb}$  from (2). This contradicts the hypothesis that  $\lambda_{wb} \leq \lambda_{bw}$ , so  $\lambda_{bw} < \lambda_{wb}$  in any equilibrium.

Now consider any equilibrium pair  $(\lambda_{bw}, \lambda_{wb})$  and the corresponding thresholds  $(\tilde{\gamma}_{bw}, \tilde{\gamma}_{wb})$ . Note that since  $\lambda_{bw} < \lambda_{wb}$ , we have  $\tilde{\gamma}_{wb} < \tilde{\gamma}_{bw}$ . Define the sequence  $\{\gamma_n\}_{n=0}^{\infty}$  as follows:  $\gamma_0 = \tilde{\gamma}_{wb}$  and

$$\gamma_n = G_{bb}(\gamma_{n-1}) \quad (18)$$

for  $n \geq 1$ . Since (13) holds with strict inequality,

$$G_{bb}(\gamma) = G_{wb}(\gamma) > G_{bw}(\gamma) = G_{ww}(\gamma). \quad (19)$$

Using this together with (5), and  $\tilde{\gamma}_{wb} < \tilde{\gamma}_{bw}$ , we get

$$\gamma_1 = G_{bb}(\tilde{\gamma}_{wb}) = G_{wb}(\tilde{\gamma}_{wb}) = \tilde{\gamma}_{bw} > \tilde{\gamma}_{wb} = \gamma_0$$

so  $\gamma_0 < \gamma_1$ . This, together with the fact that  $\gamma_n$  is increasing in  $\gamma_{n-1}$  from (18), and satisfies  $\gamma_n < \delta$  from (6), implies that  $\{\gamma_n\}_{n=0}^{\infty}$  is an increasing sequence that converges to a point  $\gamma_{\infty} \in (\gamma_1, \delta] = (\tilde{\gamma}_{bw}, \delta]$ . This limit point satisfies

$$\gamma_{\infty} = G_{bb}(\gamma_{\infty}),$$

and hence  $\gamma_{\infty} = \tilde{\gamma}_{bb}$ , where  $\tilde{\gamma}_{bb}$  is an equilibrium corresponding to interactions in which both individuals are black. We have therefore proved that  $\tilde{\gamma}_{bb} > \tilde{\gamma}_{bw} > \tilde{\gamma}_{wb}$ , and hence from (2) and (13) that

$$\lambda_{bb} = F_{bb}(\tilde{\gamma}_{bb}) > F_{bb}(\tilde{\gamma}_{wb}) = F_{wb}(\tilde{\gamma}_{wb}) = \lambda_{wb}$$

as required.

The proof that  $\lambda_{bw} > \lambda_{ww}$  follows similar reasoning. Define the sequence  $\{\gamma'_n\}_{n=0}^{\infty}$  as follows:  $\gamma'_0 = \tilde{\gamma}_{bw}$  and

$$\gamma'_n = G_{ww}(\gamma'_{n-1})$$

for  $n \geq 1$ . Using (19) together with (5) and  $\tilde{\gamma}_{wb} < \tilde{\gamma}_{bw}$ , we get

$$\gamma'_1 = G_{ww}(\tilde{\gamma}_{bw}) = G_{bw}(\tilde{\gamma}_{bw}) = \tilde{\gamma}_{wb} < \tilde{\gamma}_{bw} = \gamma'_0$$

so  $\gamma'_1 < \gamma'_0$ . This, together with the fact that  $\gamma'_n$  is increasing in  $\gamma'_{n-1}$  from (18), and satisfies  $\gamma'_n \geq 0$  from (6), implies that  $\{\gamma'_n\}_{n=0}^{\infty}$  is a decreasing sequence that converges to a point  $\gamma'_{\infty} \in [0, \gamma'_1] = [0, \tilde{\gamma}_{wb})$ . This limit point satisfies

$$\gamma'_{\infty} = G_{ww}(\gamma'_{\infty}),$$

and hence  $\gamma'_{\infty} = \tilde{\gamma}_{ww}$ , where  $\tilde{\gamma}_{ww}$  is an equilibrium corresponding to interactions in which both individuals are white. We have therefore proved that  $\tilde{\gamma}_{ww} < \tilde{\gamma}_{wb} < \tilde{\gamma}_{bw}$ , and hence from (2) and the fact that (13) holds with strict inequality, we have

$$\lambda_{ww} = F_{ww}(\tilde{\gamma}_{ww}) < F_{ww}(\tilde{\gamma}_{bw}) = F_{bw}(\tilde{\gamma}_{bw}) = \lambda_{bw}$$

as required.

To prove the second claim, note that  $\lambda_{ww} < \lambda_{bw} < \lambda_{wb} < \lambda_{bb}$  implies

$$\begin{aligned} m_{bw} &= \lambda_{bw} (\lambda_{wb}q + (1 - \lambda_{wb})p) < \lambda_{wb} (\lambda_{wb}q + (1 - \lambda_{wb})p) = \varphi(\lambda_{wb}) < \varphi(\lambda_{bb}) = m_{bb}, \\ m_{wb} &= \lambda_{wb} (\lambda_{bw}q + (1 - \lambda_{bw})p) > \lambda_{bw} (\lambda_{bw}q + (1 - \lambda_{bw})p) = \varphi(\lambda_{bw}) > \varphi(\lambda_{ww}) = m_{ww}. \end{aligned}$$

Hence  $m_{bw} < m_{bb}$  and  $m_{wb} > m_{ww}$ . Define  $\alpha_b = \eta + (1 - \eta)\beta$  and note that  $m_b = \alpha_b m_{bb} + (1 - \alpha_b)m_{bw}$ . An increase in  $\eta$  raises  $\alpha_b$  and, since  $m_{bw} < m_{bb}$ , also raises  $m_b$ . An increase in  $\beta$  has the same effect. Similarly, note that  $m_w = \alpha_w m_{ww} + (1 - \alpha_w)m_{wb}$  where  $\alpha_w = \eta + (1 - \eta)(1 - \beta)$ . An increase in  $\eta$  raises  $\alpha_w$  and since  $m_{ww} < m_{wb}$ , it lowers  $m_b$ . On the other hand an increase in  $\beta$  lowers  $\alpha_w$  and hence raises  $m_b$ .  $\blacksquare$

**Proof of Proposition 3.** The reasoning follows closely that in the proof of Proposition 2 so we present it here in abbreviated form. First we show that  $\lambda_{bw} > \lambda_{wb}$ . Suppose not, so  $\lambda_{wb} \geq \lambda_{bw}$  and therefore  $\tilde{\gamma}_{bw} \geq \tilde{\gamma}_{wb}$ . Using this with (14) we get

$$\lambda_{wb} = F_{wb}(\tilde{\gamma}_{wb}) \leq F_{wb}(\tilde{\gamma}_{bw}) < F_{bw}(\tilde{\gamma}_{bw}) = \lambda_{bw},$$

a contradiction. Hence  $\lambda_{bw} > \lambda_{wb}$ .

Now consider any equilibrium pair  $(\lambda_{bw}, \lambda_{wb})$  with corresponding thresholds  $(\tilde{\gamma}_{bw}, \tilde{\gamma}_{wb})$ . Since  $\lambda_{bw} > \lambda_{wb}$ , we have  $\tilde{\gamma}_{wb} > \tilde{\gamma}_{bw}$ . Define the sequence  $\{\gamma_n\}_{n=0}^\infty$  as follows:  $\gamma_0 = \tilde{\gamma}_{bw}$  and  $\gamma_n = G_{bb}(\gamma_{n-1})$  for  $n \geq 1$ . Note that (14) implies

$$G_{bb}(\gamma) = G_{bw}(\gamma) > G_{wb}(\gamma) = G_{ww}(\gamma). \quad (20)$$

Using this with (5), and  $\tilde{\gamma}_{wb} > \tilde{\gamma}_{bw}$ , we get

$$\gamma_1 = G_{bb}(\tilde{\gamma}_{bw}) = G_{bw}(\tilde{\gamma}_{bw}) = \tilde{\gamma}_{wb} > \tilde{\gamma}_{bw} = \gamma_0$$

Since  $\gamma_n$  is increasing in  $\gamma_{n-1}$  and bounded above by  $\delta$ ,  $\{\gamma_n\}_{n=0}^\infty$  is therefore an increasing sequence that converges to a point  $\gamma_\infty \in (\gamma_1, \delta] = (\tilde{\gamma}_{wb}, \delta]$ . This limit satisfies

$$\gamma_\infty = G_{bb}(\gamma_\infty),$$

and hence  $\gamma_\infty = \tilde{\gamma}_{bb}$ , where  $\tilde{\gamma}_{bb}$  is an equilibrium of  $\Gamma_{bb}$ . We have therefore proved that  $\tilde{\gamma}_{bb} > \tilde{\gamma}_{wb} > \tilde{\gamma}_{bw}$ , and hence from (2) and (14) that

$$\lambda_{bb} = F_{bb}(\tilde{\gamma}_{bb}) > F_{bb}(\tilde{\gamma}_{bw}) = F_{bw}(\tilde{\gamma}_{bw}) = \lambda_{bw}$$

as required.

To complete the proof define  $\{\gamma'_n\}_{n=0}^\infty$  as follows:  $\gamma'_0 = \tilde{\gamma}_{wb}$  and  $\gamma'_n = G_{ww}(\gamma'_{n-1})$  for  $n \geq 1$ . Using (20) together with (5) and  $\tilde{\gamma}_{wb} > \tilde{\gamma}_{bw}$ , we get

$$\gamma'_1 = G_{ww}(\tilde{\gamma}_{wb}) = G_{wb}(\tilde{\gamma}_{wb}) = \tilde{\gamma}_{bw} < \tilde{\gamma}_{wb} = \gamma'_0$$

Since  $\gamma'_n$  is increasing in  $\gamma'_{n-1}$  from (18) and satisfies  $\gamma'_n \geq 0$  from (6),  $\gamma'_1 < \gamma'_0$  implies that  $\{\gamma'_n\}_{n=0}^\infty$  is a decreasing sequence that converges to a point  $\gamma'_\infty \in [0, \gamma'_1] = [0, \tilde{\gamma}_{bw})$ . This limit satisfies

$$\gamma'_\infty = G_{ww}(\gamma'_\infty),$$

and hence  $\gamma'_\infty = \tilde{\gamma}_{ww}$ , where  $\tilde{\gamma}_{ww}$  is an equilibrium corresponding to interactions in which both individuals are white. We have therefore proved that  $\tilde{\gamma}_{ww} < \tilde{\gamma}_{bw} < \tilde{\gamma}_{wb}$ , and hence from (2) and (14) that

$$\lambda_{ww} = F_{ww}(\tilde{\gamma}_{ww}) < F_{ww}(\tilde{\gamma}_{wb}) = F_{wb}(\tilde{\gamma}_{wb}) = \lambda_{wb}$$

as required.

To prove the second claim, note that  $\lambda_{ww} < \lambda_{wb} < \lambda_{bw} < \lambda_{bb}$  implies

$$\begin{aligned} v_{bw} &= \lambda_{wb}(\lambda_{bw}q + (1 - \lambda_{bw})p) < \lambda_{wb}(\lambda_{wb}q + (1 - \lambda_{wb})p) = \varphi(\lambda_{wb}) < \varphi(\lambda_{bb}) = v_{bb}, \\ v_{wb} &= \lambda_{bw}(\lambda_{wb}q + (1 - \lambda_{wb})p) > \lambda_{bw}(\lambda_{bw}q + (1 - \lambda_{bw})p) = \varphi(\lambda_{bw}) > \varphi(\lambda_{ww}) = v_{ww}, \end{aligned}$$

so  $v_{bw} < v_{bb}$  and  $v_{wb} > v_{ww}$ . Note that  $v_b = \alpha_b v_{bb} + (1 - \alpha_b) v_{bw}$ , where  $\alpha_b = \eta + (1 - \eta)\beta$ . An increase in  $\eta$  raises  $\alpha_b$  and since  $v_{bw} < v_{bb}$ , also raises  $v_b$ . An increase in  $\beta$  has the same effect. Similarly, note that  $v_w = \alpha_w v_{ww} + (1 - \alpha_w) v_{wb}$  where  $\alpha_w = \eta + (1 - \eta)(1 - \beta)$ . An increase in  $\eta$  raises  $\alpha_w$  and since  $v_{wb} > v_{ww}$ , it lowers  $v_w$ . On the other hand an increase in  $\beta$  lowers  $\alpha_w$  and hence raises  $v_w$ . ■

## References

- [1] Aldy, Joseph, and W. Kip Viscusi, 2003, "The value of a statistical life: a critical review of market estimates throughout the world," *Journal of Risk and Uncertainty* 27: 5-76.
- [2] Almgren, G., A. Guest, G. Immerwehr, and M. Spittel, 1998, Joblessness, family disruption, and violent death in Chicago, 1970-1990, *Social Forces* 76: 1465-93.
- [3] Anderson, Elijah, 1990, *Streetwise: Race, Class and Change in an Urban Community*. Chicago: University of Chicago Press.
- [4] Baliga, Sandeep, and Tomas Sjoström, 2004, "Arms races and negotiations," *Review of Economic Studies* 71: 351-69.
- [5] Baliga, Sandeep, David O. Lucca, and Tomas Sjoström, 2007, "Domestic political survival and international conflict: Is democracy good for peace?" Unpublished Manuscript, Northwestern University.
- [6] Becker, Gary and Kevin Murphy, 2000, *Social Economics*. Cambridge, MA: Harvard University Press.
- [7] Bowles, Samuel, Glenn C. Loury and Rajiv Sethi, 2008, "Group Inequality." Unpublished Manuscript, Barnard College, Columbia University.
- [8] Kristin F. Butcher and Anne Morrison Piehl, 2007, "Why are immigrants' incarceration rates so low? Evidence on selective immigration, deterrence, and deportation," NBER working paper 13229.
- [9] Butcher, Kristin and Anne Morrison Piehl, 2008, "Crime, Corrections and California: What does immigration have to do with it?" *California Counts* 9 (3). San Francisco: Public Policy Institute of California.
- [10] Chandra, Amitabh, 2003, "Is the convergence of the racial wage gap illusory?" NBER working paper 9476.
- [11] Chaudhuri, Shubham and Rajiv Sethi (2008). "Statistical Discrimination with Peer Effects: Can Integration Eliminate Negative Stereotypes?" *Review of Economic Studies* 75: 579-596.
- [12] Cook, Philip J., 1986, The demand and supply of criminal opportunities, *Crime and Justice* (Michael Tonry, ed.). University of Chicago Press, 1-27.
- [13] Cubbin, Catherine, Linda Williams Pickle, and Lois Fingerhut, 2000, Social context and geographic patterns of homicide among U.S. black and white males, *American Journal of Public Health* 90 (4): 579-87.
- [14] Drake, St. Clair, and Horace R. Cayton, 1945 (1962), *Black Metropolis. A Study of Negro Life in a Northern City*. New York: Harcourt and Brace. 2nd edition: Harper Torchbook.

- [15] Fryer, Roland G., Paul S. Heaton, Steven D. Levitt, and Kevin M. Murphy, 2005, "Measuring the impact of crack cocaine," NBER working paper 11318.
- [16] Glaeser, Edward L., and Bruce Sacerdote, 2000, "The determinants of punishment: Deterrence, incapacitation, and vengeance," Harvard University Department of Economics, HIER discussion paper 1894.
- [17] Glaeser, Edward L., Bruce I. Sacerdote, and Jose A. Scheinkman, 1996, "Crime and social interactions," *Quarterly Journal of Economics* 111(2): 507-48.
- [18] Glaeser, Edward L., Bruce I. Sacerdote, and Jose A. Scheinkman, 2003, "The social multiplier," *Journal of the European Economic Association* 1 (2-3): 345-53.
- [19] Goldin, Claudia, and L. Katz, 2002, "The power of the pill: Oral contraception, and women's career and marriage decisions," *Journal of Political Economy* 110 (4): 730-70.
- [20] Guryan, Jonathan, 2004, Desegregation and black dropout rates, *American Economic Review* 94 (4): 919-43.
- [21] Hawkins, Darnell, 1987, "Devalued lives and racial stereotypes: Ideological barriers to the prevention of violence among blacks." In Robert L. Hampton, ed., *Violence in the Black Family*, pp. 189-206. Lexington, MA: Lexington.
- [22] Lewis Mumford Center, State University of New York at Albany, 2001, Data. Accessed on April 2, 2009 at <http://mumford.albany.edu/census/index.html>.
- [23] Lochner, Lance and Enrico Moretti, 2004, The effect of education on crime: Evidence from prison inmates, arrests, and self-reports, *American Economic Review* 94 (1): 155-89.
- [24] Logan, John R., 2002, "Separate and Unequal: The Neighborhood Gap for Blacks and Hispanics in Metropolitan America," report, Lewis Mumford Center for Comparative Urban and Regional Research, SUNY-Albany.
- [25] Miron, Jeffrey A., 1999, "Violence and the U.S. prohibitions of drugs and alcohol," *American Law and Economics Review* 1 (1-2): 78-114.
- [26] Myrdal, Gunnar, 1944 (1998). *An American Dilemma: The Negro Problem and Modern Democracy*. New Brunswick, NJ: Transaction Publishers.
- [27] National Center for Health Statistics, 2006, Health, United States, 2006. Hyattsville, MD: the Center.
- [28] Neal, Derek, 2005, "Why has black-white skill convergence stopped?" NBER working paper 11090.
- [29] O'Flaherty, Brendan and Rajiv Sethi, 2008, "Racial Stereotypes and Robbery." *Journal of Economic Behavior and Organization* 68: 511-524.

- [30] O’Flaherty, Brendan and Rajiv Sethi, 2010a “Peaceable kingdoms and war zones: Preemption, ballistics and murder in Newark,” in Rafael Di Tella, Sebastian Edwards, and Ernesto Scharrotsky, eds., *The Economics of Crime: Lessons for Latin America*, University of Chicago Press, forthcoming.
- [31] O’Flaherty, Brendan and Rajiv Sethi, 2010b, “The Racial Geography of Street Vice” *Journal of Urban Economics*, forthcoming.
- [32] Parker, R.N., 1989, “Poverty, subculture of violence, and type of homicide,” *Social Forces* 67: 983-1007.
- [33] Rennison, Callie Marie and Sarah Welchans, 2000, Bureau of Justice Statistics Special Report: Intimate Partner Violence, accessed at <http://bjs.ojp.usdoj.gov/index.cfm?ty=pbdetail&iid=1002>.
- [34] Rogers, Richard G., Rebecca Rosenblatt, Robert A. Hummer, and Patrick M. Krueger, 2001, "Black-white differentials in adult homicide mortality in the United States," *Social Science Quarterly* 82: 435-52.
- [35] Sampson, R.J., 1987, “Urban black violence: The effect of male joblessness and family disruption,” *American Journal of Sociology* 93: 348-82.
- [36] Schelling, Thomas C., 1960. *The Strategy of Conflict*. Cambridge, MA: Harvard University Press.
- [37] Shihadeh, Edward S. and Nicole Flynn, 1996, "Segregation and crime: The effect of black isolation on the rates of black urban violence," *Social Forces* 74 (4): 1325-52.
- [38] Shin, Yongsook, Davor Jedlicka, and Everett S. Lee, 1977, Homicide among blacks, *Phylon* 38: 398-407.
- [39] U.S. Bureau of the Census, 2004, Statistical Abstract. Washington, DC: U.S. Government Printing Office.
- [40] U.S. Bureau of the Census, 2009a, American Fact-Finder, American Community Survey, 2005-2007 Three Year Average.
- [41] U.S. Bureau of the Census, 2009b, Education. Accessed on June 28, 2009 at [www.census.gov/population/socdemo/education/cps2006](http://www.census.gov/population/socdemo/education/cps2006).
- [42] U.S. Bureau of the Census, 2009c, America’s Family and Living Arrangements. Accessed on June 28, 2009 at [www.census.gov/population/socdemo/hh-fam/cps2008](http://www.census.gov/population/socdemo/hh-fam/cps2008).
- [43] U.S. Bureau of Justice Statistics, National Criminal Victimization Survey.
- [44] US Bureau of Justice Statistics, 2006, Prisoners in 2005. Bulletin NCJ 215092. Washington, DC: U.S. Department of Justice.

- [45] US Bureau of Justice Statistics, 2007, Homicide trends in the United States. Accessed on July 10, 2007 at [www.ojp.usdoj.gov/bjs/homicide/race.htm](http://www.ojp.usdoj.gov/bjs/homicide/race.htm)
- [46] US Bureau of Justice Statistics, 2009, “Local level homicide trends and characteristics.” Accessed February 2, 2009 at <http://bjsdata.ojp.usdoj.gov/dataonline/Search/Homicide/Local/LocalHomicide.cfm>
- [47] Venkatesh, Sudhir Alladi, 2006, *Off the Books: The Underground Economy of the Urban Poor*. Cambridge, MA: Harvard University Press.
- [48] Webster, Jr., Bruce H., and Alemayehu Bishaw, U.S. Census Bureau, 2007, Earnings and Poverty Data from the 2006 American Community Survey, ACS-08. Washington: U.S. Government Printing Office. Accessed on March 25, 2008 at [www.census.gov/prod/2007pubs/acs-08.pdf](http://www.census.gov/prod/2007pubs/acs-08.pdf)
- [49] Weiner, David A., Byron F. Lutz, and Jens Ludwig, 2009, The effects of school desegregation on crime, National Bureau of Economic Research working paper 15380.
- [50] Wilbanks, William, 1986, “Criminal homicide offenders in the U.S.: Black vs. white,” pp. 43-53 in Darnell F. Hawkins, ed., *Homicide among Black Americans*. Lanham, MD: University Press of America.
- [51] Wolfgang, M.E., and F. Ferracuti, 1967, *The Subculture of Violence*. London: Tavistock.