NBER WORKING PAPER SERIES

THE DEMAND FOR PROTECTION AND THE PERSISTENTLY HIGH RATES OF GUN VIOLENCE AMONG YOUNG BLACK MALES

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Working Paper 29969
http://www.nber.org/papers/w29969

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2022

We wish to thank Ivan Balbuzanov, Jamein Cunningham, Craig Garthwaite, Jens Ludwig, Tim Moore, Alberto Ortega, Morgan Williams Jr., and Richard Zeckhauser, for very helpful comments on an earlier draft of this paper. The authors declare that they have no relevant or material financial interests that relate to the research described in this paper. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 29969
April 2022
JEL No. C7,C72,K4,K42

ABSTRACT

We develop a theoretical model to explain both the high level and persistence in gun violence for black males ages 15–24 consistent with the empirical literature. A person may carry a gun for instrumental (i.e., criminal) reasons or for its perceived protective benefit. Discerning underlying motives is difficult. A shock to the instrumental benefit can move the equilibrium to one with a high gun prevalence. The model demonstrates that there are larger returns to reducing the value of guns for crime than trying to reduce their protective benefit, suggesting different policy paths to combat the problem of gun violence.

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1 Introduction

Murder rates of young black males, adolescents and young men between the ages of 15 and 24, are substantially higher than almost any other demographic group in the United States.[1] In 2020, the murder rate for this group, expressed as deaths per 100,000 population, was 108. This is 17 times higher than the rate for people not in this demographic, which is 6.3. A more dispiriting fact is the murder rate today for this group is 33 percent more than the rate of 81 in 1968. In comparison, over the last half century, murder rates of black men 25–34 and 35-plus have fallen by 26 and 55 percent, respectively.

Two key question for social scientists are why is the level of violence in the young black male population so high and how has this level of violence persisted for so long? The first question has been answered in part by a numerous authors and we summarize the arguments and underlying data in the next section. The violence in this population is driven by guns. As we outline below, by the end of our sample, 97 percent of murders of young black males are via guns, a rate substantially larger than the rate for the general population. Surveys spanning nearly forty years suggests that young black males carry guns at high rates primarily as protection against others who are also armed (Wright et al., 1992; Fontaine et al., 2018; Swaner et al., 2020). With so many people carrying weapons, disagreements are settled with deadly consequences.

Given this background, our primary interest is to build a theoretical model that explains the high level and persistence of gun violence among young black males. We do so using a tipping point or threshold model driven by strategic complementarities. Application of such models to sociological phenomena was pioneered by Schelling (1969, 1971, 1978) and Granovetter (1978) and our theoretical analysis closely aligns with their underlying intuition and structure. In our model, individuals choose to carry a gun or not and they come into contact with others that make the same decision. Among those with guns, some behave passively while others are aggressive and pose a threat. A novelty of our model is that a person's choice to arm is determined by an interaction of two intrinsic motives. Guns are instrumentally valuable to persons with criminal intent, especially when confronting others who are not armed. Guns also carry a perceived protective benefit for some, either as an ex ante deterrent or as an ex post equalizer in a difficult situation. These two dimensions broadly characterize four types of people. At the extremes, some never arm and others—criminals—always do. In these

[1]Throughout this paper, we will refer to this demographic group as *young black males*. We use the term "males" instead of "men" because many of the victims and perpetrators of violence are 15–17 years-olds and hence, they are adolescents and not men.

cases, instrumental and protective rationales unambiguously reinforce each other either for or against guns. In the middle are persons whose best choice depends on others' behavior. Some (marginal) criminals can be deterred from using a gun if doing so is likely to be very dangerous, i.e., it is likely others also have guns. And, some people will arm for protection, but only if the community is sufficiently dangerous to warrant doing so. The interaction among these types can lead to a tipping point. A small shock increasing the prevalence of guns can precipitate a large run up in carry rates and subsequent gun use. Though driven by a defensive rationale, the latent degree of danger increases as a person's motives for being armed are not easily discernible to others.

To derive specific predictions from our model, we specialize to the case where the two dimensions of a person's type follow a bivariate normal distribution. If the average instrumental value of carrying a gun is low, gun carry rates are also low. As that value increases, the equilibrium carry rate shifts dramatically. The problem is that returning to a low-gun equilibrium among non-criminals is difficult. The situation can be understood as a coordination failure. Most non-criminals would be better off if everyone stopped carrying guns, but getting there is difficult without a coordinating device. Hence, gun violence persists.

The comparative statics are troubling. Once a high gun carry equilibrium is reached, large drops in the benefits of carrying a gun are necessary to revert to a low gun equilibrium. Furthermore, an important asymmetry prevails. The equilibrium gun carry rate, and (by implication in our model) the level of danger and violence, is much more sensitive to changes in the average instrumental value of a gun than its average defensive value, even though the vast majority who arm do so for perceived protection. Our reading of the existing gun policy research suggests these conclusions conflict with real-world policy options in that it has been easier for policy makers to attempt to change the costs of owning guns for non-criminals than criminals. These results suggest the problem may be particularly difficult to solve through legislative means.

Two closely-related papers that share both our motivation and general modelling approach are O'Flaherty and Sethi (2010a,b). Both models rely on strategic complementarities in agents' decisions to arm to amplify the level of danger (and by implication, murders) in the populations under study. Our model relies on the same dynamic. The model of O'Flaherty and Sethi (2010b) is closest to ours. The authors focus on the near doubling of murders in Newark, New Jersey, from 2000 to 2006. They argue that many of these murders were motivated by self protection and were "preemptive killings" to avoid being killed first. The authors propose a model where individuals choose the lethality of their weapon (if any). Increasing levels of danger encourage the selection of more lethal weapons; past some tipping point, murders rise rapidly. This rise is driven by a spiraling dynamic since "an increase in the likelihood of being killed by someone raises the incentives to kill them first" (p. 306). Multiple equilibria are possible, including those with high levels of danger and murder.

Some of our conclusions echo those of O'Flaherty and Sethi, such as the importance of multiple equilibria and the possibility of hysteresis. Nevertheless, our study builds upon distinct fundamentals. Weapon lethality and a preemptive motive are absent from our framework. These features are likely of central concern in gang-related murders, but seem peripheral for non-gang-related cases that are the majority of incidents.[2] Thus, we propose a simpler model with only a binary choice to arm or not. Instead, we emphasize multidimensional preference heterogeneity, a novel feature of our model. These dimensions capture distinct offensive (i.e., criminal) and defensive rationales for being armed. This allows for a more comprehensive assessment of policy options since different interventions target these dimensions with varying degrees of effectiveness.

The next section summarizes the existing data and establishes three related points supporting our analysis: (i) the level and persistence of gun violence among young black males,[3] (ii) the salience of the protection motive, and (iii) the prevalence of guns in this population. Together, these give context to our analysis and motivate our modelling strategy.

In section 3, we present our model. After demonstrating its main features with a parametric example, we examine its comparative statics. Even a temporary shock in the population's modal preference can lead to a persistent shift in equilibrium. A shock contributing to the current situation was the introduction of crack drug markets in the late 1980s (Blumstein, 1995; Blumstein and Cork, 1996; Kennedy et al., 1996; Evans et al., 2016, 2022). Given the violence and demographics surrounding the drug trade, young black males not in the drug trade started carrying guns for protection. Our model lets us understand its persistent impact on murder rates, especially among young black males. Two extensions of our model are also examined. The first introduces heterogeneous groups into our framework. It explains differences in observed outcomes between, for example, younger and older black males (see above). We show that inter-group interactions serve as a pathway for shock spillovers, though they can also

[2]The National Violent Death Reporting System (NVDRS) tracks the circumstances of murders. Thirty-four states reported to the NVDRS over the 2010–19 period. In this sample, 17.6 percent of murders of black males 15–24 with known circumstances were identified as gang-related. NVDRS data is available online ⟨https://wisqars.cdc.gov/nvdrs/⟩.

[3]Earlier analyses of the time series of murder rates for young black males include Blumstein (1995), Blumstein and Cork (1996), Cook (1998), Cook and Laub (1998), Cork (1999), and Evans et al. (2016). We update this data through 2020.

play a moderating role. The second extension addresses misperceptions of others' actions. There is prevalent overestimation of gun carry rates among young black males (Hemenway et al., 2011). This compounds the perception of fear and encourages armament for protection. Our model shows that information interventions are unlikely to succeed in countering this dynamic.

Sections 4 and 5 conclude our analysis. We relate our model to the existing literature on gun policy and examine the challenges in addressing the issue of gun violence with traditional policy interventions.

2 Gun Violence Among Young Black Males

2.1 Trends in Murder Rates

In Figure 1, we graph the national murder rate as reported by the National Vital Statistics Data (NVSD) from 1968 through 2020.[4] The time series was volatile for the first 23 years with peaks in 1974, 1980, and 1992. The national murder rate declined consistently from 1992 through 2015, with a substantial increase after that, especially in 2020 when murder rates for the nation rose by 27 percent, more than twice the second largest annual percent increase in the murder rate in the series. The rate in 2020 is about the same as it was in 1968 and the number for 2019 was 20 percent lower than the value in 1968. In the same graph, we also report the gun and non-gun murder rates. The variation in murders over time is driven mainly by changes in gun murders. Of the increase between 1968 and 1992, 81 percent was attributable to gun violence and of the decline from 1992 to 2015, 65 percent was due to a drop in gun murders.

The murder rate for black males differs fundamentally in level and time series than the rest of the country.[5] In Figure 2, we report the national time series from 1968 through 2020 for murder rates among black males in three age groups: 15–24, 25–34, and 35-plus. The murder

[4]The data for these time series come from the CDC Wonder database ⟨https://wonder.cdc.gov⟩. We use the Compressed Mortality data ⟨https://wonder.cdc.gov/mortSQL.html⟩for 1968–1998 and Multiple Cause of Death data ⟨https://wonder.cdc.gov/mcd-icd10.html⟩for 1999–2020. In the figure titles, we refer to this data as CDC Wonder. Deaths were classified by the ICD-8 system 1968–1978, ICD-9 from 1979–1998, and ICD-10 from 1999–2020. The codes for homicides were E960–E969 for ICD-8 and ICD-9 and X85-Y09 for ICD-10. In the ICD-8 system there is a single code for assault deaths from firearms and explosives (E965). Starting with ICD-9, there were separate codes for firearms (E965.0–E965.4) and explosives (E965.5–E965.9). The gun and explosive codes in ICD-10 are X93–X95 (firearms) and X96 (explosives). To obtain a consistent series, we include homicides from explosives in with guns in both the ICD-9 and ICD-10 series to match the coding in the ICD-8 series. This should not be an issue as there were only 69 homicides in total for the nation from explosives for 22-year period 1999–2020.

[5]In more recent years, the NVSD data identifies Hispanic origin as an ethnicity. In the early years of this series, they do not. Therefore, to maintain a consistent sample definition over time, murder rates for black and white victims will include data for Hispanics.

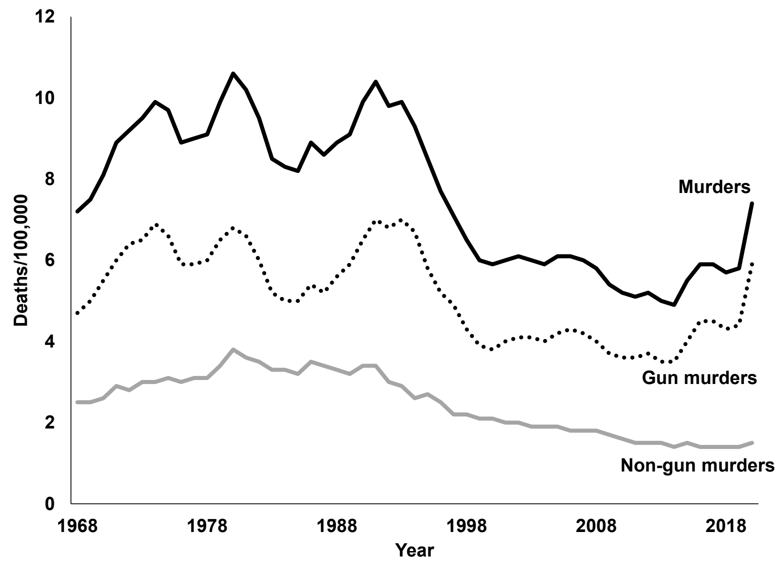


Figure 1: Murder rates in the United States, 1968–2020, CDC Wonder Data.

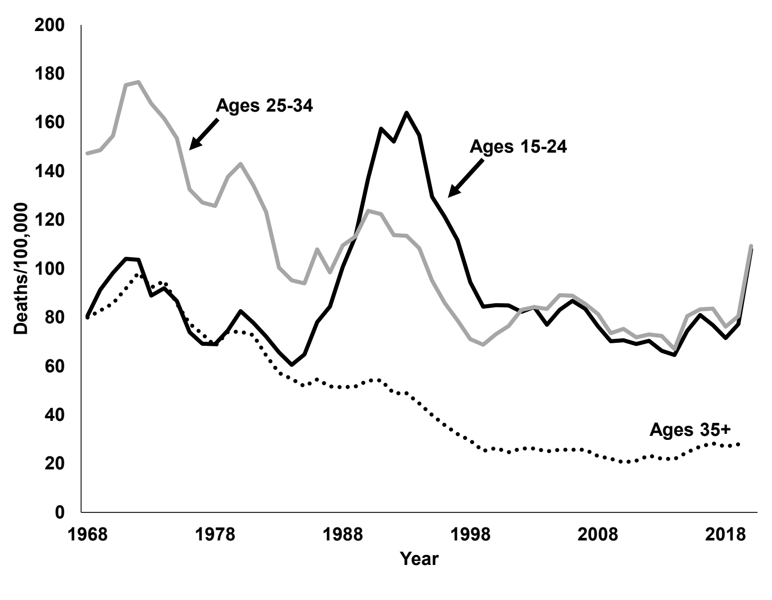


Figure 2: Murder rates in the United States for black males by age group, 1968–2020, CDC Wonder Data.

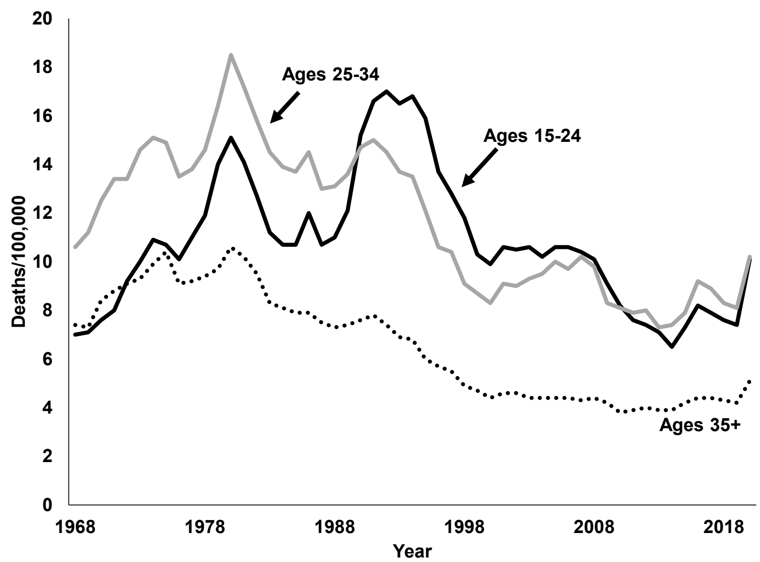


Figure 3: Murder rates in the United States for white males by age group, 1968–2020, CDC Wonder Data.

rate for older black men has fallen from 98.3 in 1972 to a low of 21.2 in 2010, a drop of 78 percent. Since 2010, the murder rate in this group has edged up, but is still 63 percent below its peak and 55 percent lower than the 1968 value. The murder rate for black men in the 25–34 age category has been much more volatile, seeing peaks almost every decade. The long term trend is decidedly negative. Between 1968 and 2020, murder rates fell 26 percent. The peak (176.6 in 1972) to trough (67.7 in 2014) changes represents a 62 percent decline.

The numbers for young black males follow a completely different series. Between 1978 and 1994 there was a 137 percent increase in murders, then over the next 21 years, murder rates fell by 60 percent. However, the murder rate in 2019 (77) was at about the same as it was in 1968 (81) and the rate and the rate in 2020 (108) is 33 percent higher than in 1968. This is a staggering difference compared to the rest of the country. The rate in 2020 is 17 times what it is for people not in that demographic. Although young black males are about 1 percent of the population, the fraction of murders in this group represented 17 percent of murders in 1994 and 17 percent in 2020.

For completeness, we report in Figure 3 the same graph for white male. The basic time series patterns are quite similar to those of black males. The startling distinction between Figures 2 and 3 is the scale. The murder rates for black men are roughly 10 times higher than the rate for white men in most years.

The time series movement in the murder rate for young black males is driven almost ex-

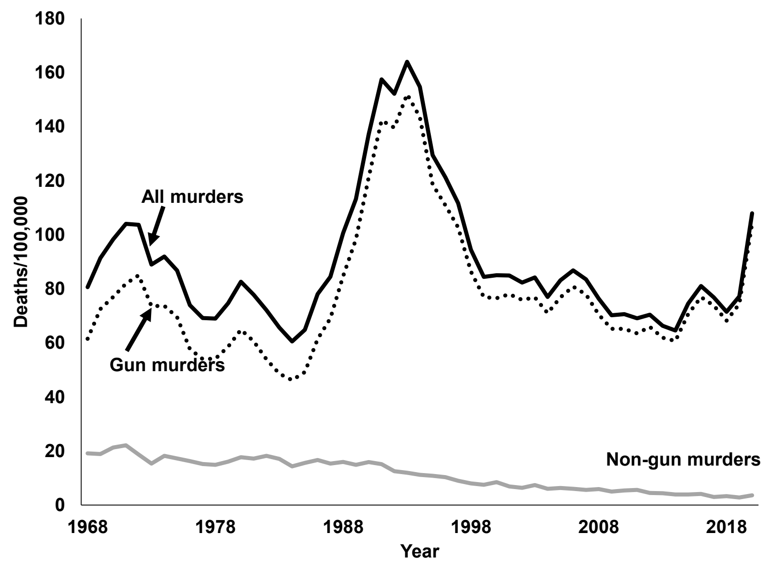


Figure 4: Murder rates in the United States for black males ages 15–24 by type of murder, 1968–2020, CDC Wonder Data.

clusively by gun violence. In Figure 4, we report the murder rate, the gun murder rate and the non-gun murder rate for this group since 1968. The non-gun murder rate has fallen steadily since 1968. In contrast, the overall murder rate essentially follows the gun murder rate. Moreover, the fraction of murders attributable to guns is now much higher than 50 years ago, climbing from about three-quarters of murders in 1968 to 98 percent in 2020.

2.2 A Demand for Protection

In surveys spanning 40 years, the number one reason young black males carry guns is for protection. Wright et al. (1992) surveyed 1,663 inner-city youths (ages 14–20) in California, Illinois, Louisiana, and New Jersey in the early 1990s at the height of the crack epidemic. One-third of the respondents were black males. Of these youths, 36.8 percent reported they carry a gun at least "now and then." Respondents that carry a weapon were asked 12 questions about the reasons for the activity. They were also asked to indicate whether the reason was very important, somewhat important, or not important at all. In our analysis of their raw data, the reason with far and away the highest fraction of very or somewhat important responses was "you have to be ready to defend yourself." The next closest was "you are prepared for anything that might happen" at 60 percent while the least frequent response was "sometimes, I use weapons to commit crimes" at 19 percent.[6] Wright et al. (1992) conclude that "the desire

[6]Their data is available from Sheley et al. (1995).

for protection and the need to arm oneself against enemies were the primary reasons to obtain a gun, easily outpacing all other motivations" (p. 88).

Moving forward nearly four decades, recent surveys show that personal protection is still the primary reason young black males carry guns. In 2017, Fontaine et al. (2018) conducted a survey of 345 young adults ages 18–26 from Chicago's south and west. Ninety-six percent of the respondents were black and one-third reported to carry a gun, a number similar to the 1992 survey reported above. When asked why they carry a gun, several options with Likert scales were offered with the two top categories in the scale being "agree" or "strongly agree." The three top reasons in that survey were "for self-protection" (93 percent agree or strongly agree); "to protect friends/family members" (84 percent); and "for protection of business" (27 percent). Swaner et al. (2020) conducted a similar study in New York City of youths aged 16–24 that were at high risk of gun violence: those that had been shot at and those that carried a gun. In this survey, 79 percent were men and 74 percent were black. In this survey, 87 percent had owned or carried a gun at some point, and of this group, 71 percent said "family would want me to defend myself if attacked" and 52 percent said they are "less likely to be a victim with a gun."

Another possible reason young black males carry guns is general protection against police. In Swaner et al. (2020) and Fontaine et al. (2018), respondents had rather low opinions of the quality of policing. In the former study, respondents felt the police were too aggressive at arresting youths for minor offenses and spent too little time worrying about violent crime. In the qualitative comments from respondents, some noted they carry guns to protect themselves from the police. The events of 2020 highlight the risks black men and adolescents face from police shootings. Data from the 1999 through 2020 Vital Statistics indicate that black males ages 15 and up are 2.4 times as likely to die from a police intervention than white males of a similar age.[7] That said, the chance of murder by peers is substantially larger than the death from police. From 1999 through 2020, the death rate from legal intervention for young black males was about 1/100,000 with no discernible trend.[8] In contrast, the murder rate for this group over the same period was 78/100,000. Even if we were to double or triple the risk of death from police interventions following the work cited above, the risk is still a fraction of the risk of death from non-police.

The need for protection is driven in part by the fact that the primary perpetrators of mur-

[7]Deaths from legal interventions in the ICD-10 period are coded as Y35 (legal interventions) except Y35.5 (legal executions) and Y89.0 (sequelae of legal intervention).

[8]Feldman et al. (2017) argue the NVSD understate deaths from the police by 50 percent. Using different data, Edwards et al. (2018a) argue these numbers are understated by a factor of 3.2 to 3.5.

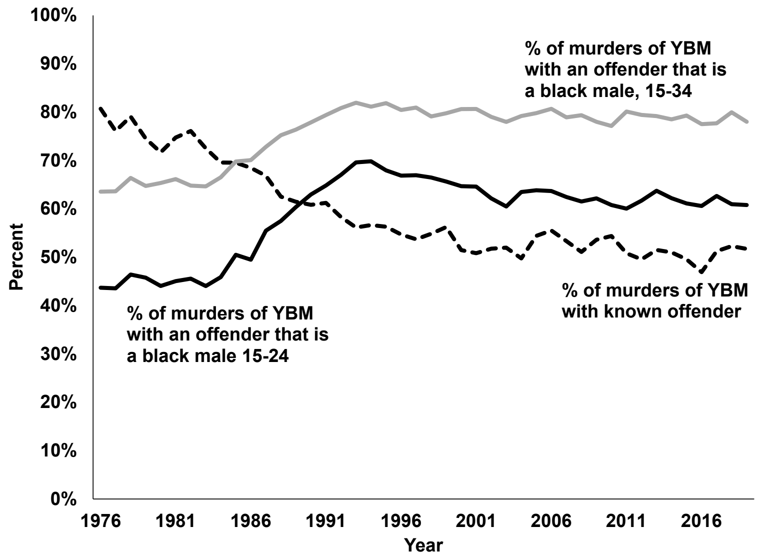


Figure 5: Percent of murders of black males ages 15–24 (YBM) with known offenders and the percent of murders with known offenders committed by black males in various age ranges, Supplemental Homicide Reports, 1976–2019.

ders of young black males are other young black males. To document this, we use the FBI's Supplemental Homicide Reports (SHR).[9] In Figure 5, the black dashed line reports the fraction of murders of young black males from 1976 to 2019 where an offender is identified in the SHR. This has declined steadily over time from 80 to about 52 percent. In the same graph, the solid line reports the fraction of murders of young black males with known offender where at least one of the offenders is from this same demographic group. This number starts at 44 percent in 1976 rises to 70 percent in 1994 and has been near 60 percent since 2002. When we increase the age range by another decade, the fraction known offenders that are black males ages 15–34 has been hovering around between 77 and 81 percent since 1992.

2.3 Gun Availability

Figure 4 notes that by the 2000s, the overwhelming majority of murders of young black males is by gun and the year-to-year variation in murders is driven primarily by gun deaths. Unfor-

[9]We use a version of the SHR with data from 1976 to 2019 that was compiled by Kaplan (2021). The data reports information about the date, location, method of murder, and demographic information of victims (age, race, sex, and ethnicity). When the offender is known, the SHR reports the same demographic information for the offender as well as the relationship between the offender and victim and the circumstances surrounding the murder. We delete homicides classified as "manslaughter by negligence" and delete all deaths in the data associated with the 9/11 terrorist attacks. This latter correction is not necessary in the Multiple Cause of Death data because by 1999, the ICD-10 system had separate codes for assaults leading to death (X85–Y09) and terrorist attacks leading to a homicide (U01).

tunately, there is poor data on gun ownership or gun carry rates of sufficient sample size to obtain a time series for this small demographic. However, the public health literature has devised a proxy for gun ownership: the ratio of firearm suicides (FS) divided by total suicides (S), known as FS/S (Cook, 1979; Kleck and Patterson, 1993; Hemenway and Miller, 2000; Miller et al., 2002a,b; Cook and Ludwig, 2006). The success of the proxy is driven by the fact that many suicide attempts are impulsive actions and gun suicide attempts have a high likelihood of success (Miller and Hemenway, 2008).[10] There is a strong cross-sectional relationship between gun ownership rates and suicides at the state and regional levels in the US (Cook, 1979; Azrael et al., 2004; Miller et al., 2002a,b; Kaplan and Geling, 1998; Killias, 1993). The evidence on gun availability and suicides is mixed. Kellermann et al. (1992) found that a gun in the home increased the risk of a death by suicide by a factor of five, with the gun/suicide gradient steepest for those aged 24 and under. The evidence on gun availability from alterations in gun laws is mixed. Edwards et al. (2018b) found mandatory delays in handgun purchases and Lang (2013) found backgrounds checks for gun purchases reduced gun suicides. In contrast, Duggan et al. (2011) found that gun shows increase gun sales but had no short-term impact on suicide rates. Duggan (2003) found no correlation between gun magazine subscriptions rates, a proxy for gun ownership, and suicides. Leigh and Neill (2010) found that the states that had the most guns sold back to the government as part of an Australian gun buyback policy had the sharpest fall in suicides.

In Figure 6, we provide some evidence of the validity of FS/S as a proxy for gun possession that is consistent with the prior literature. The horizontal axis measures the fraction of adults by state that live in a home with a gun. This data is from the Behavioral Risk Factors Surveillance Survey (BRFSS) in 2001, 2002 and 2004, pooled across all three years.[11] These surveys asked respondents "Are there any firearms kept in or around the house?" On the vertical axis, we plot the state-level gun FS/S ratio (in percent) for adults aged 18 and older in the years 2001, 2002, and 2004 from the CDC Wonder data.[12] In the scatter plot, the observation is scaled by

[10]Estimates suggest that a quarter to 40 percent of suicide attempts occur within five minutes of a person's decision to commit suicide (Simon et al., 2001; Williams et al., 1980). Deisenhammer et al. (2009) estimates that nearly 50 percent of attempts occur within 10 minutes of an initial decision to attempt suicide. Spicer and Miller (2000) estimate that 82.5 percent of suicide attempts with are gun are fatal.

[11]BRFSS is a nationwide, telephone-based survey of adults aged 18 and older. The surveys are administered by states and aggregated in to one dataset by the Centers for Disease Control and Prevention. These are large surveys and the average respondents per year in these three years is 255,000. More information is available about BRFSS at ⟨https://www.cdc.gov/brfss/index.html⟩.

[12]The codes for suicides in ICD-8/9 are E950–E959 while the codes in the ICD-10 era are X60–X84. As with murders, in the ICD-8/9 series, suicides by firearm and explosives were pooled together in one code, while these were separate codes in the ICD-10 series. To generate a comparable series, our suicide by gun measure includes deaths by explosives. The code for suicide by firearm or explosives in ICD-8/9 is E955 while codes the codes in

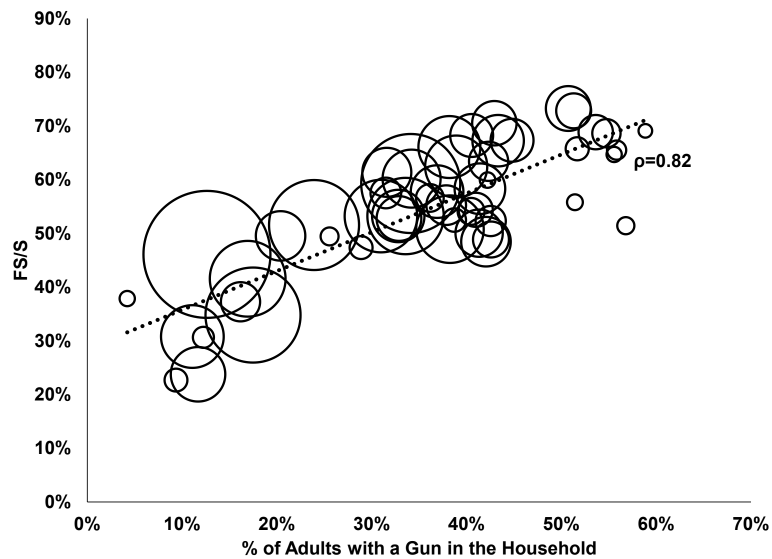
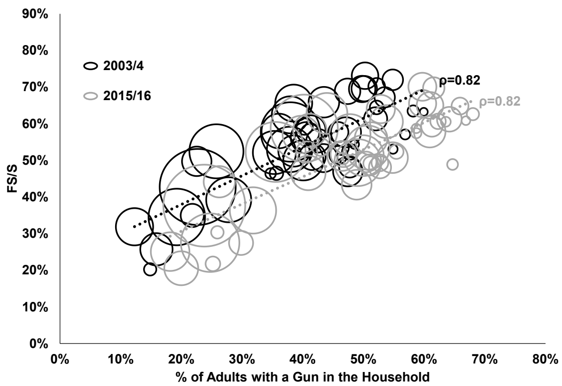


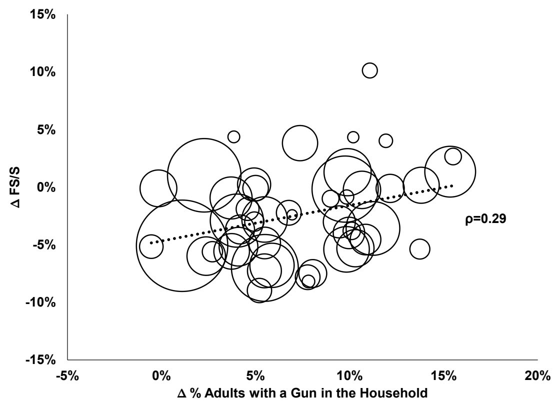
Figure 6: Scatter plot of the percent of adults that report a gun in the home at the state level from (2001, 2002 and 2004 Behavioral Risk Factors Surveillance Survey) and the FS/S Rate (in percent) for the same year (CDC Wonder Data).

state population and the regression line is weighted by average state population over the three years. There is a strong positive relationship between these two variables, with a correlation coefficient of 0.82.

The cross-sectional relationship could be contaminated by omitted variables. For example, do more rural and western states have high suicides because they have high gun ownership or do the factors that lead to high gun ownership also lead to more gun suicides? To get some handle on this, we construct long differences in gun ownership rate and the FS/S and correlate them at the state level. The Pew Foundation has routinely added questions about whether individuals have access to a gun in the household to their surveys. This questions was asked in surveys in 2003/4 and 2015/16. Each of the individual surveys were small (1,500 to 2,000 observations) so they were not designed to be representative at the state level. We take a simple average of the rate across two years to form an estimate for 2003/4 and another for 2015/16. In Figure 7a, we report the cross sectional correlations for the two pooled groups using the FS/S at the state level calculated from CDC Wonder. The black circles represent data for 2003/4 and the gray lines are data for the later periods. Although this sample is smaller than the BRFSS surveys, they convey the same basic story. In Figure 7b, we first-difference

ICD-10 are X73–X75. This restriction should pose little problem in our analysis in that there were only 133 suicide deaths by explosives from 1999 through 2020 for the entire country.





(a) Correlation at the state level between gun availability and FS/S, 2003/4 and 2015/16.

(b) Correlation at state level between the change in gun availability and change in FS/S, 2015/16–2003/4.

Figure 7: Scatter plots of state-level estimates of gun availability (Pew Surveys in 2003/4 and 2015/16), and state-level estimates of FS/S (CDC Wonder Data) for the same years.

the data and provide correlation in long differences in FS/S and gun availability from 2015/16 minus 2003/4. This correlation coefficient is 0.29.

The importance that gun availability plays in the changes in murder rates for young black males is displayed in Figure 8 where we report the murder rate (left axis) with the FS/S rate (right axis) for black males 15–24 from 1968–2020. The series track each other exceedingly well, even matching the turning points. The recent rise in murders since 2015 is also matched by a rises in the FS/S. At the cross-sectional level, research has demonstrated that the availability of guns as measured by FS/S predicts well the gun carry rates for adolescents. Cook and Ludwig (2004) use geocoded data from the 1995 National Survey of Adolescent Males and show that gun carry rates are highly correlated with the FS/S for those aged 15 to 19.

3 Model

Our goal in this section is to build a model that explains the observed facts about gun violence outlined in the previous section. To that end, consider a large population where agent i interacts with some other agent j at random. The parties are ex ante symmetric. An agent's only choice, made in advance of any interaction, is whether to be armed with gun (g) or not (n). Even if both parties are armed or have ready access to a weapon, it is possible that their interaction unfolds without incident. Each party may even be oblivious to the other's choice. At random, however, events unfold unfavorably leading to danger, injury, or possibly death. We

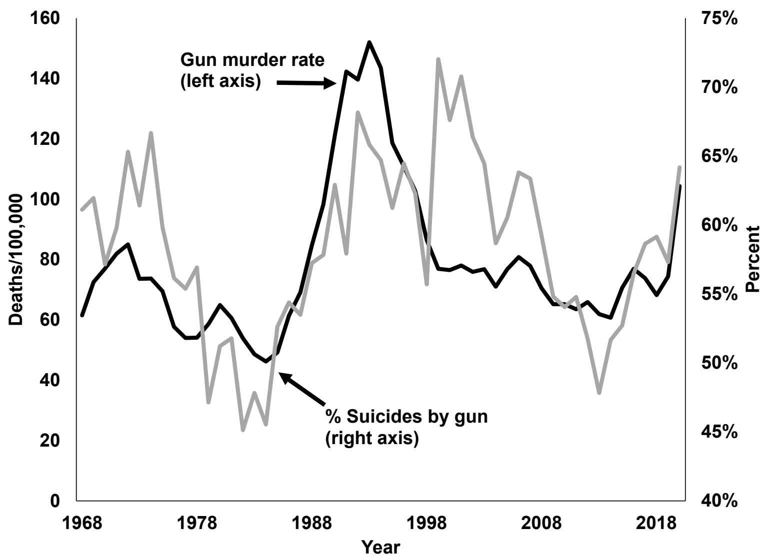


Figure 8: Gun murder rate and FS/S (in percent) for black males 15–24, 1968–2020, CDC Wonder Data.

model this unfortunate turn as a shock affecting each agent's disposition, mood, or willingness and ability to use force. For simplicity, we describe this disposition as either aggressive or passive. An agent's disposition is a spur of the moment shock and it is not known to him when deciding between g or n. However, with probability α_i agent i will be aggressive. This likelihood is known only to agent i and varies in the population.

Table 1: Payoffs of agent i interacting with agent j.

			Agent j		
			g		n
			Aggressive (α_j)	Passive ($1-\alpha_j$)	
Agent i	g	Aggressive (α_i)	v_i^{gg}	v_i^{gn}	v_i^{gn}
		Passive ($1-\alpha_i$)	v_i^{ng}	v_i^{nn}	v_i^{nn}
	n		v_i^{ng}	v_i^{nn}	v_i^{nn}

Table 1 presents agent i's payoffs from interacting with agent j as a function of his choice, agent j's choice, and their idiosyncratic dispositions. The latter realize with appropriate probabilities. The values in the table include any material or psychic costs related to the decision and the final outcome. This includes any expected consequences or benefits from the interaction.[13] Like α_i, the values in Table 1 are agent i's private information and differ from person to person. For example, we would typically expect that $v_i^{nn} > v_i^{ng}$, i.e., an unarmed agent i is better off if agent j is unarmed or is passive. However, the magnitude of this payoff difference will necessarily vary.

To simplify the analysis, we constrain each agent's payoffs in a particular way in Table 1. Namely, we equate the payoff of an armed but passive person with those of someone who is unarmed. That is, if agent i is armed but (by chance) passive, it is *as if* he is unarmed. This is a reasonable first-order approximation, though it may fail if carrying a gun gives a utility boost beyond its instrumental or protective value, discussed below. This assumption biases agents against carrying a gun and relaxing it would reinforce many of our conclusions.

Notwithstanding the aforementioned simplification, our definition of payoffs nevertheless allows for rich agent-level preference heterogeneity. Anticipating the analysis below, two important dimensions of heterogeneity are defined by

$$x_i := v_i^{gg} - v_i^{ng} \qquad \text{and} \qquad y_i := v_i^{gn} - v_i^{nn}.$$

The value x_i measures agent i's *protection* or defensive motive when meeting others. If $x_i > 0$, then agent i prefers to be armed when agent j is armed and aggressive. The converse is true if $x_i < 0$. The value y_i measures the *instrumental* benefit of being armed when others are not armed or are passive. This benefit may accrue through a criminal exploit or through some other status-enhancing dynamic. If $y_i > 0$, being armed is instrumentally valuable; otherwise, it is not. For ease of discussion, we may refer to y_i as measuring criminality.

Together, x_i and y_i describe four distinct types of people. If x_i and y_i are both positive, then agent i always benefits from armament. Conversely, if both are negative, then agent i never sees a reason to be armed. The remaining cases are the most interesting and define people with more nuanced motives. Loosely, we may describe a person for whom $x_i < 0$ and $y_i > 0$ as a *deterrable* criminal. This person values a weapon for its instrumental benefit when dealing with the unarmed, but will stand down if he is likely to encounter others who are armed. Conversely, $x_i > 0$ and $y_i < 0$ reflects a *protective* instinct. Such a person has no criminal intent per se and chooses g only if he is likely to encounter others who are armed.

As demonstrated below, the values x_i and y_i are sufficient to characterize agent i's behavior and we define the triple $\theta_i := (\alpha_i, x_i, y_i)$ as agent i's private *type*. When appropriate, we distinguish agent i's type as a random variable (versus its realized value) with a tilde, i.e.,

[13] For example, suppose agent i chooses n while agent j picks g and is aggressive. Many events can unfold—agent i might be a victim of a crime, agent i may "come out ahead" despite being unarmed, the interaction may be uneventful, etc. The payoff v_i^{ng} is agent i's payoff accounting for all (not modelled) possibilities.

$\widetilde{\theta}_i = (\widetilde{\alpha}_i, \widetilde{x}_i, \widetilde{y}_i)$. For analytic ease, we henceforth maintain the following assumptions.

Assumption 1. *Each agent's type is independently and identically distributed. This distribution is common knowledge.*

Assumption 2. *For each agent i, $\widetilde{\alpha}_i$ is independent of $(\widetilde{x}_i, \widetilde{y}_i)$.*

Assumption 3. *For each agent i, the distribution of $(\widetilde{x}_i, \widetilde{y}_i)$ is atomless with full support on an open subset of $\mathbb{R}^2$ that includes the origin. The expectation of $(\widetilde{x}_i, \widetilde{y}_i)$ exists.*

Next, we consider agent i's decision. Fix agent i's type and suppose he believes agent j will be armed with probability $\widetilde{p}_j \equiv p_j(\widetilde{\theta}_j)$. Agent i's expected payoff from g is

$$\mathbb{E}\Big[\widetilde{\alpha}_j \widetilde{p}_j \cdot \Big(\alpha_i v_i^{gg} + (1-\alpha_i) v_i^{ng}\Big) + (1-\widetilde{\alpha}_j \widetilde{p}_j) \cdot \Big(\alpha_i v_i^{gn} + (1-\alpha_i) v_i^{nn}\Big)\Big]. \tag{1}$$

His expected payoff from selecting n is

$$\mathbb{E}\big[\widetilde{\alpha}_j \widetilde{p}_j \cdot v_i^{ng} + (1-\widetilde{\alpha}_j \widetilde{p}_j) \cdot v_i^{nn}\big]. \tag{2}$$

The action g is preferred if and only if

$$\begin{aligned}
(1) \geq (2) \iff & \mathbb{E}\big[\widetilde{\alpha}_j \widetilde{p}_j \cdot \big(\alpha_i v_i^{gg} - \alpha_i v_i^{ng}\big) + (1-\widetilde{\alpha}_j \widetilde{p}_j) \cdot \big(\alpha_i v_i^{gn} - \alpha_i v_i^{nn}\big)\big] \geq 0 \\
\iff & \mathbb{E}\Big[\widetilde{\alpha}_j \widetilde{p}_j \cdot \underbrace{\big(v_i^{gg} - v_i^{ng}\big)}_{x_i} + (1-\widetilde{\alpha}_j \widetilde{p}_j) \cdot \underbrace{\big(v_i^{gn} - v_i^{nn}\big)}_{y_i}\Big] \geq 0 \\
\iff & \mathbb{E}[\widetilde{\alpha}_j \widetilde{p}_j] \cdot x_i + (1 - \mathbb{E}[\widetilde{\alpha}_j \widetilde{p}_j]) \cdot y_i \geq 0.
\end{aligned} \tag{3}$$

Except for knife-edge cases occurring with probability zero, agent i's optimal action is uniquely determined by (3). Thus, we can assume he follows a pure strategy that is a function of (x_i, y_i) and the term $\mathbb{E}[\widetilde{\alpha}_j \widetilde{p}_j]$. Importantly, agent i's action is independent of α_i, his own proclivity for aggression. By symmetry, this fact is true for everyone. Set $\alpha := \mathbb{E}[\widetilde{\alpha}_j]$ to be the average aggressiveness in the population and $p := \mathbb{E}[\widetilde{p}_j]$ as the probability that a typical agent j is armed. With this notation, (3) simplifies to

$$\alpha p \cdot x_i + (1-\alpha p) \cdot y_i \geq 0. \tag{4}$$

It is helpful to interpret this expression in relation to the four categories of agents described above. Inequality (4) partitions the type space, as illustrated in Figure 9. The partition is downward sloping and passes through the origin with slope $\alpha p/(\alpha p - 1)$. If agent i's type (x_i, y_i) is north-east this line, it is optimal for him to select g. Otherwise, he selects n. As alluded above, some types always arm (quadrant I); others never do (III). Deterrable (II) and protective (IV) types are on the margin and their behavior responds to the aggregate behavior of others. Here, the value αp plays a critical role. Intuitively, this value captures the perceived aggregate danger in society. If α is high, others are likely to be aggressive; if p is high, others are likely to have

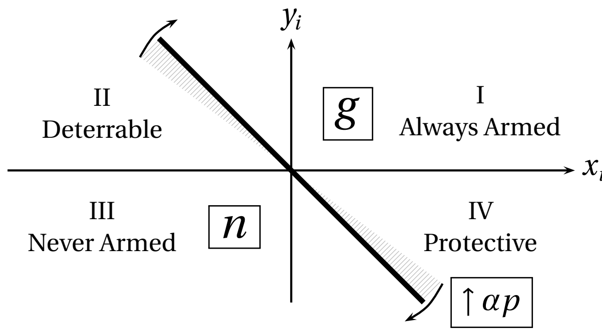


Figure 9: Preferred action of agent i as a function of (x_i, y_i). An increase in αp rotates the partition clockwise.

the means, i.e., a weapon, to cause harm. An increase in αp rotates the partition in Figure 9 *clockwise*. More people with protective intentions decide to arm and those who are deterrable back down.

Inequality (4) implies the ex ante probability that agent i selects g is

$$\gamma(p) := \Pr\left[\alpha p \cdot \tilde{x}_i + (1-\alpha p) \cdot \tilde{y}_i \geq 0\right]. \tag{5}$$

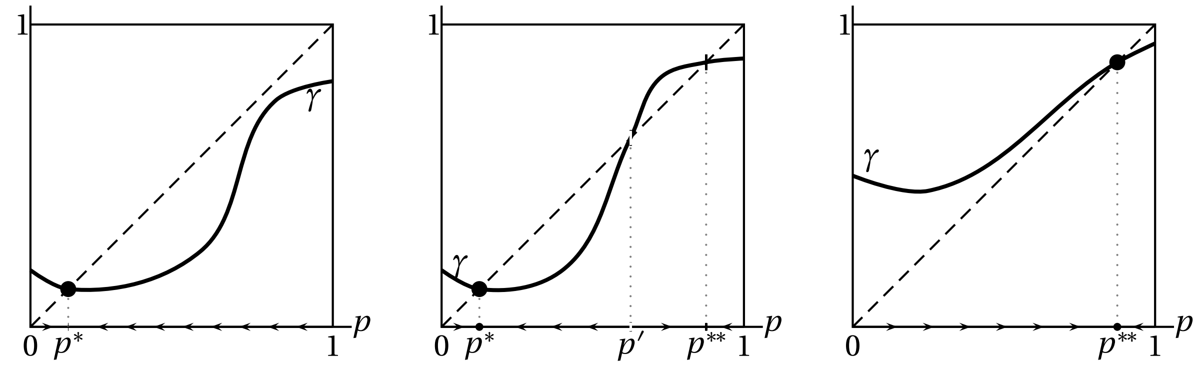
The value $\gamma(p)$ is the proportion of the population for whom g is optimal when fraction p of others are armed. It is the fraction of the population lying to the north-east of the diagonal partition in Figure 9. The shape of the function $\gamma(p)$ will depend on the distribution of $(\tilde{x}_i, \tilde{y}_i)$ and may be irregular. Often, however, it has an "S-shape," which is presumed in Figure 10. The supporting intuition is that of strategic complements, where the return of taking an action increases with the proportion of others also taking that action. Empirically, this seems to be the most plausible case in our application. Among teens and young adults, gun carry rates are positively related to the individual's perceived level of gun carry rates among peers and neighbors (Hemenway et al., 2011; Bailey et al., 1997; Sheley et al., 1992; Williams et al., 2002). The function $\gamma(p)$ is increasing when the number of people drawn to g for protection exceeds the number deterred by the higher gun prevalence. When $\gamma(p)$ is decreasing, the deterrent effect of guns dominates.

An equilibrium requires that the proportion of agents selecting g equals the fraction finding it optimal to do so. That is, p^* is an *equilibrium* if and only if

$$\gamma(p^*) = p^*.$$

Thus, an equilibrium occurs wherever the function $\gamma(p)$ intersects the 45°-line. There always exists at least one equilibrium.[14] An equilibrium p^* is *regular* if the function $\gamma(p)$ strictly

[14] Since $(\tilde{x}_i, \tilde{y}_i)$ is continuously distributed, $\gamma : [0,1] \to [0,1]$ is a continuous function. The intermediate value theorem ensures that there is a $p^* \in [0,1]$ such that $\gamma(p^*) = p^*$.



(a) A stable equilibrium at p^*.

(b) Stable equilibria separated by an unstable equilibrium at p'.

(c) A stable equilibrium at p^{**}.

Figure 10: Representative cases of the baseline model as the function $\gamma(p)$ shifts upward.

crosses the 45°-line at p^*. Equilibria that are not regular arise when $\gamma(p)$ is tangent to the 45°-line at p^*. These are not generic and we henceforth focus on regular equilibria only.

A regular equilibrium p^* is *stable* if $\gamma(p)$ crosses the 45°-line at p^* from above; it is *unstable* if the crossing is from below.[15] This equilibrium classification follows standard tâtonnement reasoning related to the dynamic system

$$\dot{p} = \gamma(p) - p. \tag{6}$$

Equation (6) describes how the fraction of people choosing g changes in response to the fraction who find it optimal to choose g. If the fraction finding g optimal exceeds p, i.e., $\gamma(p) > p$, then p will increase over time as agents adjust their behavior. Conversely, if $\gamma(p) < p$, p will fall.[16] If p is in the neighborhood of a stable equilibrium p^*, this adjustment process means it converges to p^*. At an equilibrium, $\dot{p} = 0$ and further changes do not occur. In Figures 10a and 10c, there is a unique stable equilibrium. There are two stable equilibria in Figure 10b, at low (p^*) and high (p^{**}) levels of armament. These are separated by an unstable equilibrium at p'. A small nudge to the left (right) of p' sets off an adjustment to the equilibrium at p^* (p^{**}).

The following proposition echoes similar results in other applications. Its proof is omitted.

Proposition 1. *Generically, there is an odd number of regular equilibria. When there is a unique regular equilibrium, then it is stable; otherwise regular equilibria alternate between stable and unstable varieties.*

[15] Formally, p^* is stable if there is an $\epsilon > 0$ such that $p \in (p^* - \epsilon, p^*) \implies \gamma(p) > p$ and $p \in (p^*, p^* + \epsilon) \implies \gamma(p) < p$. The inequalities are reversed if it is unstable.

[16] The gradual adjustment process described here differs from that in Granovetter (1978), which involves discrete best-response dynamics. A discrete process may not to converge to a point in our model.

3.1 The Normal Case

A more precise examination of the model is possible if we assume $(\tilde{x}_i, \tilde{y}_i)$ is bivariate normal:

$$\begin{pmatrix} \tilde{x}_i \\ \tilde{y}_i \end{pmatrix} \overset{\text{i.i.d.}}{\sim} \mathcal{N}\left(\begin{pmatrix} \mu_x \\ \mu_y \end{pmatrix}, \begin{pmatrix} \sigma_x^2 & \rho\sigma_x\sigma_y \\ \rho\sigma_x\sigma_y & \sigma_y^2 \end{pmatrix} \right).$$

This case is indicative of our model's properties whenever $(\tilde{x}_i, \tilde{y}_i)$ has a unimodal distribution. The values (μ_x, μ_y) are the expectation of $(\tilde{x}_i, \tilde{y}_i)$ and define the modal preference in the population. These values are determined by the population's demographic, social, and economic characteristics and likely vary from community to community. They can also be affected by government policy. Since the payoffs in Table 1 are inclusive of the psychic or material cost of each action, any policy that impedes access to weapons can be modeled as downward shift of (μ_x, μ_y).[17] Conversely, changes that ease weapons access shift (μ_x, μ_y) up. Policies may also move μ_x and μ_y independently. For example, a change in the expected return to criminal behavior (e.g., a change in apprehension probability) will affect μ_y but not μ_x.

As an empirical matter, it is most natural to assume that $\mu_y \leq 0$ since few people attach instrumental value to being armed (distinct from a defensive rationale) when interacting with others. The correct sign for μ_x is less obvious. It it likely negative (i.e., the defense motive is not salient for most people), but it may be near zero or possibly positive in some cases. The latter possibility may be relevant for young black males in light of the evidence cited above concerning the importance of the protection motive. Nevertheless, as shown below, a positive value for μ_x is *not* necessary to sustain an equilibrium with a high level of guns. The remaining parameters concern preference dispersion. Among these parameters, the most interesting is the correlation parameter ρ. A positive correlation reflects a general predisposition or aversion to armament.

We can derive $\gamma(p)$ when $(\tilde{x}_i, \tilde{y}_i)$ is bivariate normal. The random variable

$$\tilde{z}_i = \alpha p \cdot \tilde{x}_i + (1 - \alpha p) \cdot \tilde{y}_i$$

is normally distributed with mean $\mu_z = \alpha p \mu_x + (1 - \alpha p)\mu_y$ and variance $\sigma_z^2 = (\alpha p)^2 \sigma_x^2 + (1 -$

[17] Recall that $x_i = v_i^{gg} - v_i^{ng}$ and $y_i = v_i^{gn} - v_i^{nn}$, where the v_i's are the payoffs of agent i from Table 1. If a policy imposes a cost of d on acquiring a gun, then the payoffs from selecting g_i would be $v_i^{gg\prime} = v_i^{gg} - d$ and $v_i^{gn\prime} = v_i^{gg} - d$. The payoff differences are $x_i' = (v_i^{gg} - d) - v_i^{ng} = x_i - d$ and $y_i' = (v_i^{gn} - d) - v_i^{nn} = y_i - d$. Thus, the expectation of $\tilde{x}_i'$ and $\tilde{y}_i'$ are $\mu_x' = \mu_x - d$ and $\mu_y' = \mu_y - d$, respectively. This reasoning does not depend on the normality assumption; it is a translation of the distribution of $(\tilde{x}_i, \tilde{y}_i)$.

$\alpha p)^2\sigma_y^2 + 2\rho(\alpha p)(1-\alpha p)\sigma_x\sigma_y$. Since $\gamma(p) = \Pr[\tilde{z}_i \geq 0]$, it follows that

$$\gamma(p) = \Phi\left(\frac{\alpha p\mu_x + (1-\alpha p)\mu_y}{\sqrt{(\alpha p)^2\sigma_x^2 + (1-\alpha p)^2\sigma_y^2 + 2\rho(\alpha p)(1-\alpha p)\sigma_x\sigma_y}}\right), \tag{7}$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function.

Equation (7) provides a tractable platform from which we can examine our model. A natural starting point concerns agents' strategic incentives. We already alluded to the role of strategic complementarities in pushing agents toward armament. This is indeed a predominant feature, though it requires qualification. A more precise statement is that strategic complementarities "kick-in" only when gun prevalence is sufficiently high.

Proposition 2. *Suppose $(\tilde{x}_i, \tilde{y}_i)$ is bivariate normal and $\rho = 0$. The agents' actions are strategic complements at p, i.e., $\gamma'(p) \geq 0$, if and only if*

$$\frac{\alpha p}{1-\alpha p} \cdot \frac{\mu_y}{\sigma_y^2} \leq \frac{\mu_x}{\sigma_x^2}. \tag{8}$$

Inequality (8) follows from evaluating $\gamma'(p) \geq 0$, collecting terms and simplifying. Above, we noted that $\mu_y \leq 0$ is the probable case, but the appropriate sign for μ_x is debatable. There are two cases. First, if $\mu_y \leq 0 \leq \mu_x$, then $\gamma(p)$ is nondecreasing for all p. Second, if $\mu_y < 0$ and $\mu_x < 0$, then $\gamma(p)$ is increasing only when p is sufficiently large, i.e.,

$$p \geq \frac{1}{\alpha} \cdot \frac{\sigma_y^2\mu_x}{\sigma_y^2\mu_x + \sigma_x^2\mu_y}.$$

In this second case, $\gamma(p)$ is decreasing when p is small. One interpretation of this threshold is that distinct strategic incentives drive the marginal agent's decision in communities facing low and high equilibrium levels of gun crime. A deterrent effect may operate on the margin when gun prevalence is low. At a high-prevalence equilibrium, the protective incentive to arm is dominant. We revisit this point when addressing policy options in section 4.

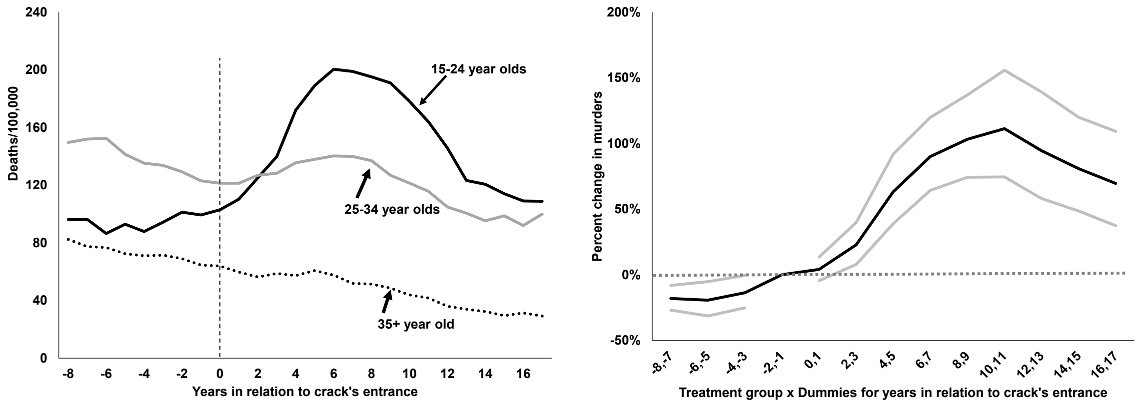
3.2 Shocks and Persistence—The Case of Crack Cocaine

The spike in murders for young black males in the late 1980s and early 1990s is dramatic. In Figure 2, murder rates for black males 15–24 peak in 1993 at 164/100,000. The spike in murders has been typically associated with the rise of crack cocaine. It solidified the murder rate of young black males at a persistently high level, decoupling it from downward trends in other populations. Shocks like this can be understood within our model as a rise in the instrumental value of weapons for criminals. In this subsection we examine such changes in greater detail using the case of crack as an important illustration.

Crack is an inhaled version of cocaine that produces a quick, intense high. It was introduced in New York City, Miami, and Los Angeles (Agar, 2003) in the 1980s and was routinely sold in small doses at low prices (Featherly and Hill, 1989; Witkin et al., 1991). Its trafficking was initially controlled by African American and Caribbean gangs operating in neighborhoods with high minority populations (Massing, 1989; Featherly and Hill, 1989; Agar, 2003). Many of those engaged in crack sales were very young. The short high, low cost, and low income of most purchasers meant that users made frequent purchases. These characteristics combined to make open air markets the preferred method of sales (Drecun and Tow, 2014). As a result, the value of franchises was tied directly to the real estate and these areas were protected by guns. Felson and Bonkiewicz (2013) found that those arrested for crack distribution were much more likely to use guns compared to other drug sales. As the original markets matured, gangs struck out for other cities and crack steadily moved to other parts of the country, bringing gun violence to new areas (Massing, 1989).

Many observers have noted that the arrival of crack brought a flood of guns to African American neighborhoods. The guns were at first held by drug dealers (Fagan and Chin, 1989). The concentration of the crack markets to largely African American neighborhoods brought many young black males not involved in the drug trade into frequent contact with those in the trade who carried guns. As protection, people started to carry guns. Blumstein (1995, p. 30) describes a vicious cycle: "Since the drug markets are pervasive in many inner-city hoods ... other young people are likely to arm themselves, primarily for their own protection .... This initiates an escalating process: as more guns appear in the community, the incentive for any single individual to arm themselves increases." The sentiment is echoed in Kennedy et al. (1996), who noted that "... it appears that the urban environment has become so threatening even for youth not involved in the drug trade that many are arming themselves" (p. 153). They conclude that, as a result, youth violence became "'decoupled' from drug and gang activity" (p. 154).

Evans et al. (2016, 2022) provide evidence that crack's emergence led to a persistent impact on murder rates. As shown in Figure 11a, murder rates of black males ages 15–24 in the 57 largest US metropolitan areas were relatively flat until the arrival of crack. Thereafter, murder rates increase rapidly and a slow decline begins eight years later. There is a similar but smaller spike for black men 25–34, but almost no discernible effect for those over 35. Using this last group as a comparison sample, Evans et al. (2022) estimate a difference-in-difference model and examine the impact of the arrival of crack on murders for young black males. We report their event-study estimates in Figure 11b as percentage changes in murders over the 2-years



(a) Murder rates for black males by age in relation to the arrival of crack cocaine in 57 large metropolitan areas (Evans et al., 2022). Year 0 is the arrival year of crack in the locality.

(b) Event study estimates (95% confidence intervals) of the impact of the arrival of crack cocaine on murder rates among black males ages 15–24 in 57 large metropolitan areas (Evans et al., 2022).

Figure 11

prior to the arrival of crack. (The gray lines are the 95 percent confidence interval.) Ten to eleven years after crack's arrival, murder rates have doubled; even 17 years after the arrival of crack, murder rates are still 50 percent higher.

The emergence of crack cocaine is a shock that can be understood in our model as a preference shift precipitating a change in the function $\gamma(p)$. The following proposition summarizes how $\gamma(p)$ and the equilibrium p^* change in response to various parameters. For simplicity, we focus on the bivariate normal case where $\gamma(p)$ is given by (7).

Proposition 3. *Suppose $(\tilde{x}_i, \tilde{y}_i)$ is bivariate normal. Let p^* be a stable regular equilibrium.*

(a) The function $\gamma(p)$ is nondecreasing[18] in μ_x and μ_y. Thus, $dp^*/d\mu_x \geq 0$ and $dp^*/d\mu_y \geq 0$.

(b) If $\rho \geq 0$ and $\mu_x, \mu_y \leq 0$, then $\gamma(p)$ is nondecreasing in σ_x and σ_y. Thus, if $\rho \geq 0$ and $\mu_x, \mu_y \leq 0$, then $dp^*/d\sigma_x \geq 0$ and $dp^*/d\sigma_y \geq 0$. The inequalities are reversed when $\mu_x, \mu_y \geq 0$.

(c) If $\mu_x, \mu_y \leq 0$, then $\gamma(p)$ is nondecreasing in ρ. Thus, $dp^*/d\rho \geq 0$. If instead $\mu_x, \mu_y \geq 0$, then $\gamma(p)$ is nonincreasing in ρ and $dp^*/d\rho \leq 0$.

(d) The function $\gamma(p)$ is not monotone in α. Thus, p^* may either increase or decrease following an increase in α.

[18] Given a parameter k, we write $\gamma(p|k)$ to stress the function's dependence on k holding other parameters fixed. We say that $\gamma(p)$ is nondecreasing in k if $k > k'$ implies $\gamma(p|k) \geq \gamma(p|k')$ for all p.

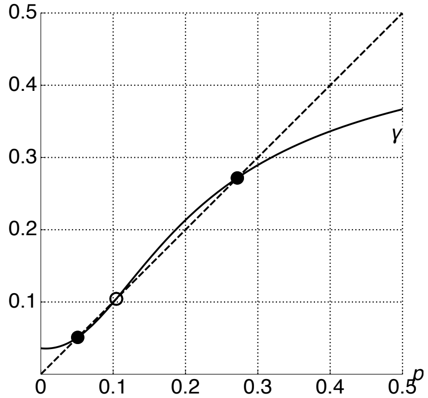
Part (a) of Proposition 3 is most useful for interpreting a shock like the influx of crack cocaine. As argued above, the crack trade led to an increase in the instrumental value of a weapon. This change in a population parameter μ_y may come about due to a change in the population's composition, such as an influx of outsiders involved in the illicit drug trade. Even a small increase in this value may be sufficient to dramatically increase the prevalence of weapons and violence in the population. Simultaneous change in the perceived protective value may reinforce this outcome, though it is not necessary for a permanent change in equilibrium. The following example illustrates the impact of changes in μ_x and μ_y.

Example 1. Assuming a bivariate normal distribution, panels (a)–(d) of Figure 12 present the function $\gamma(p)$ for different values for (μ_x, μ_y). The parameter μ_x increases from –0.9 to –0.1 moving left to right; μ_y decreases from −0.9 to −1.1 moving top to bottom. The remaining parameters are fixed at $\alpha = 0.75$, $\sigma_x = 7$, $\sigma_y = 0.5$, and $\rho = 0$. As both μ_x and μ_y are negative, the population as a whole is strongly biased *against* guns with very few having any instrumental or criminal benefit from them. Across the four cases, at most 1.8 percent of the population would fall in quadrant I of Figure 9.

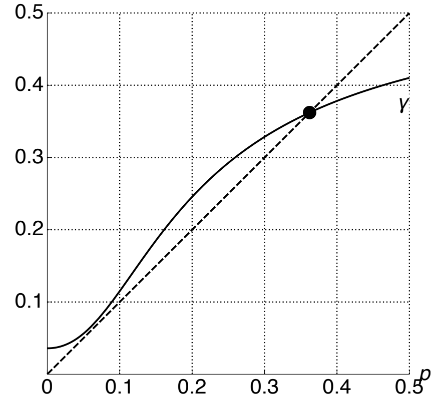
When both μ_x and μ_y are low (panel (c)), there is a unique equilibrium with a low proportion choosing to arm ($p^* = 0.014$). This is effectively everyone who values the weapon solely for its instrumental benefit. Increasing either μ_x or μ_y leads to multiple equilibria, as seen in panels (a) and (d). Despite this, the low equilibrium from panel (c) persists and increases only marginally in magnitude. It is clear that cases (a) and (d) constitute a critical juncture. Any further change in μ_x or μ_y will annihilate the low stable equilibrium, leaving only the high equilibrium, as in panel (b). Gun prevalence is significantly amplified at this equilibrium with p^* now exceeding 0.36.

A troublesome feature of the high equilibrium is that it is persistent in the sense the μ_x or μ_y must decrease dramatically once past a critical threshold to revert to a low equilibrium. To see this, consider Figure 12e, which presents the number of equilibria as a function of (μ_x, μ_y). In region A there is a single "low" equilibrium; region B has three equilibria; and region C has a unique "high" equilibrium. If (μ_x, μ_y) crosses the boundary between regions B and C, it must fall back into region A to revert to an equilibrium at a low level.

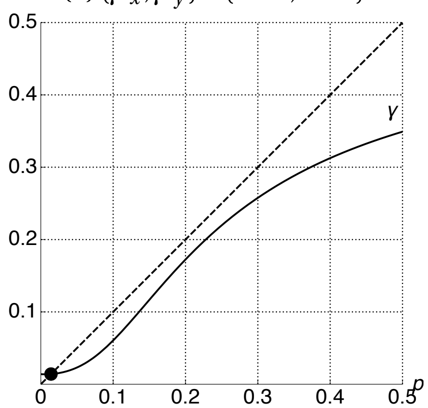
Figure 12e also highlights a significant asymmetry between the dimensions of an agent's type. Equilibrium levels of gun prevalence appear more responsive to changes in μ_y (the average criminal benefit) than μ_x (the average perceived protective benefit). For instance, starting from a "high" equilibrium in region C, μ_x must decline much more than μ_y to transition through region B to a low state in region A.



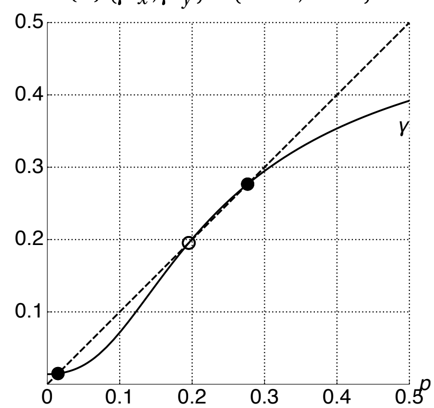
(a) $(\mu_x, \mu_y) = (-0.9, -0.9)$.



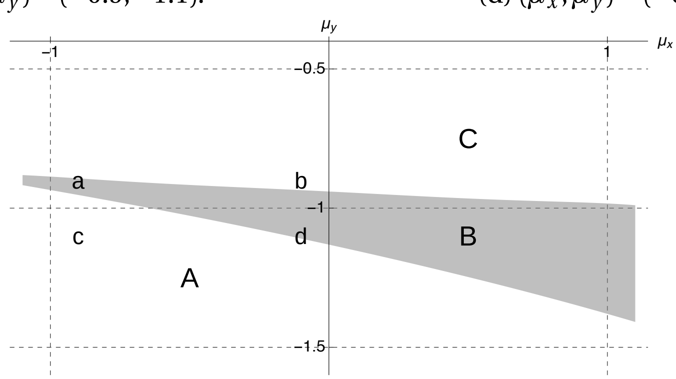
(b) $(\mu_x, \mu_y) = (-0.1, -0.9)$.



(c) $(\mu_x, \mu_y) = (-0.9, -1.1)$.



(d) $(\mu_x, \mu_y) = (-0.1, -1.1)$.



(e) Number of equilibria as a function of (μ_x, μ_y). Regions A and C—one equilibrium; region B—three equilibria. Points (a)–(d) refer to the corresponding case in panels (a)–(d).

Figure 12: Comparative statics of the function γ and equilibria with respect to μ_x and μ_y when $(\tilde{x}_i, \tilde{y}_i)$ is bivariate normal with parameters $\alpha = 0.75$, $\sigma_x = 7$, $\sigma_y = 0.5$, and $\rho = 0$.

Perhaps surprisingly, the asymmetry in equilibrium responses to changes in μ_x and μ_y holds more generally. To simplify notation, let

$$\psi^* \equiv \frac{\alpha p^* \mu_x + (1-\alpha p^*)\mu_y}{\sqrt{(\alpha p^*)^2 \sigma_x^2 + (1-\alpha p^*)^2 \sigma_y^2 + 2\rho(\alpha p^*)(1-\alpha p^*)\sigma_x \sigma_y}}.$$

Differentiating the equilibrium condition $p^* = \Phi(\psi^*)$ with respect to μ_k gives

$$\frac{dp^*}{d\mu_k} = \frac{\Phi'\left(\psi^*\right)}{1-\Phi'\left(\psi^*\right)\cdot \frac{\partial \psi^*}{\partial p^*}} \cdot \frac{\partial \psi^*}{\partial \mu_k}.$$

Evaluating the ratio $\frac{dp^*}{d\mu_x} \Big/ \frac{dp^*}{d\mu_y}$, simplifying, and rearranging terms gives

$$\frac{dp^*}{d\mu_x} = \frac{\alpha p^*}{1-\alpha p^*} \cdot \frac{dp^*}{d\mu_y}.$$

Focusing on a stable equilibrium (where the preceding derivatives are nonnegative), the equilibrium level p^* is more responsive to changes in μ_y than μ_x, i.e., $dp^*/d\mu_y > dp^*/d\mu_x$, when

$$\alpha p^* < 1/2. \tag{9}$$

Condition (9) holds for all but the most extreme and empirically implausible cases. Even if $\alpha \approx 1$, inequality (9) holds whenever less than half of the population chooses to arm at the equilibrium. This will be true of all equilibria if $\mu_x < 0$ and $\mu_y < 0$, the case assumed in Example 1 and a plausible parameter restriction more generally.

Based on the preceding analysis, the reader may wish to conclude that policy interventions that reduce the instrumental value of guns (e.g., stricter sentencing of gun crimes) will be superior at moving a community from a "high equilibrium" to one that is "low." This benefit-cost conclusion cannot be drawn from this analysis alone as it does not account for the cost differential between policies targeting the μ_x versus μ_y parameters. Moreover, many policies likely affect both parameters simultaneously, albeit to different degrees. We elaborate on policy implications in section 4 below.

3.3 Group Heterogeneity and Within-Group Interaction

The difference in murder rates across demographic groups is striking. During the 2010s, murder rates for black males ages 15–34 were roughly double those of black men over 35 and about ten times higher than white males ages 15–34. This section extends our model to accommodate disparate group outcomes. Our model thus far considers one population with preferences drawn from a single distribution. Local interactions within this population determine armament and latent danger in the community. However, it is natural to assume that different populations—defined by age, sex, race, geographic location, etc.—may *on average*

Table 2: Fraction of Known Offenders by Demographic Group for Murders of Black Males, 2010–2019, Supplemental Homicide Reports.

	Percent of Known Offenders			
Victims by Age	Black Males, 15–24	Black Males, 25–34	Black Males, 35+	Other Groups
Black Males, 15–24	61.4	16.6	7.0	15.0
Black Males, 25–34	36.4	31.7	14.6	17.3
Black Males, 35+	24.1	22.3	31.1	22.5

ascribe different values to the instrumental and protective benefit of guns. Thus, these populations' preferences would be drawn from different distributions. Depending on the intensity of within-group interaction, distinct equilibria may prevail among groups.

As an example, consider the difference in murder rates between younger and older men. Posit that the average instrumental value of a weapon declines with age, reflecting a general fall in criminality. Observing high gun prevalence among the young and low gun prevalence among the old is plausible if relevant interactions are sufficiently concentrated to limit spillovers. Table 2 highlights the importance of within-group interaction. In this table, we report the known offenders for black male victims using the Supplemental Homicide Reports. In homicides where the victim is a black male ages 15–24, 61.4 percent of known offenders are in the same demographic. This pattern persists across age brackets, though weakens slightly with age. Nevertheless, among black male victims ages 25–34, 68.1 percent of known offenders were also black males less than 34 years old.

Revisiting our model, assume for simplicity that there are now two populations. This may correspond to a stratification by age, e.g., younger/older men, or by location, e.g., inner city/suburb. Let p_k be the fraction of people in population $k \in \{1,2\}$ who choose to arm. Suppose fraction δ of a person's relevant interactions are with persons from outside his group and fraction $1-\delta$ are within-group interactions. Equation (6) describing the change in the fraction of people who arm now becomes a system of equations

$$\dot{p}_1 = \gamma_1(\delta p_2 + (1-\delta)p_1) - p_1 \qquad \dot{p}_2 = \gamma_2(\delta p_1 + (1-\delta)p_2) - p_2, \tag{10}$$

defining the co-evolution of p_1 and p_2.[19] When $\delta = 0$ there is no inter-group interaction and (10) reduces to two independent instances of the baseline model from above.

An equilibrium is a pair (p_1^*, p_2^*) such that both equations in (10) equal 0. There exists at

[19]An implicit assumption in (10) is that the α parameter is the same in both populations. Thus we can suppress "α_k" in our notation and maintain $\gamma_k(\cdot)$ as a function of the population's composition.

least one equilibrium given the maintained assumptions.[20] When the populations are symmetric, i.e., $\gamma_1 = \gamma_2$, there exists a symmetric equilibrium where $p_1^* = p_2^*$. However, asymmetric equilibria where $p_1^* \neq p_2^*$ are also possible. It is helpful to examine a parametric example to understand the model's properties more generally.

Example 2. Consider the normal model from Example 1. Assume that there are two populations, with the only difference being that group 1 places a higher average instrumental value on weapons than group 2, i.e., $\mu_{y1} > \mu_{y2}$. For concreteness, say group 1 constitutes a younger cohort, though this example is not limited to this interpretation. Let the groups' modal types be $(\mu_{x1}, \mu_{y1}) = (-0.1, -0.9)$ and $(\mu_{x2}, \mu_{y2}) = (-0.1, -1.1)$. The remaining parameters are the same as in Example 1.[21] If there is no inter-group interaction ($\delta = 0$), the equilibrium outcome of group 1 is presented in Figure 12b—there is a unique high-prevalence equilibrium. The equilibrium outcome of group 2 is presented in Figure 12d—there are multiple equilibria with low and high levels of gun prevalence.

Now suppose $\delta = 0.11$. The populations mix, but within-group contact predominates. Figure 13c sketches system (10) in the phase plane. There are five equilibria arising at points where the $\dot{p}_1 = 0$ and $\dot{p}_2 = 0$ loci cross. Three equilibria,

$$p^* = (0.066, 0.016), \; p^{**} = (0.325, 0.048), \text{ and } p^{***} = (0.356, 0.298),$$

are stable (solid points in Figure 13) and two,

$$p' = (0.084, 0.016) \text{ and } p'' = (0.329, 0.074),$$

are saddle points (hollow points). There are three types of stable equilibria. In a "low-low" equilibrium (e.g., p^*) there is a low level of gun prevalence among both groups. In a "high-low" equilibrium (p^{**}) guns are prevalent only among members of group 1. Finally, in a "high-high" equilibrium (p^{***}) both groups arm extensively.

This framework lets us examine the consequences of group-specific shocks and spillovers. Above, we documented the impact of crack cocaine on young black males and the role of guns in those markets. The late 1980s and early 1990s saw a dramatic rise in homicides in this demographic, with more muted effects among older persons (Figure 2). A similar pattern occurs among white men, though the levels differ by an order of magnitude (Figure 3). As discussed in section 3.2, we can understand this development in this example as an increase in the average instrumental value of a gun to group 1 due to some of its members' involvement

[20] The map $(p_1, p_2) \mapsto (\hat{p}_1, \hat{p}_2)$ defined by $\hat{p}_j = \gamma_j(\delta p_k + (1-\delta)p_j)$ for $j, k \in \{1, 2\}$, $j \neq k$, is a continuous function from $[0, 1]^2$ to itself. Thus, it has a fixed point (Brouwer), which is an equilibrium of (10).

[21] Specifically, $\alpha_k = 0.75$, $\sigma_{xk} = 7$, $\sigma_{yk} = 0.5$, and $\rho_k = 0$ for each $k \in \{1, 2\}$.

in the drug trade. In Figure 13, we consider the case where μ_{y1} increases from -0.9 (panels a, c, and e) to -0.89 (panels b, d, and f). If inter-group interaction is sufficient, this shock spills over and annihilates a "low-low" equilibrium leaving only a "high-high" equilibrium. In Figure 13, this corresponds to a move from panel (a) to panel (b), which assumes that $\delta = 0.12$. If inter-group interactions are less prevalent, the shock may remain contained. In Figure 13, this corresponds to a move from panel (c) to panel (d), which assumes that $\delta = 0.11$. The equilibrium carry rate increases sharply in group 1 and modestly in group 2, leading to a "high-low" equilibrium. This differential impact is consistent with the 1980s and 1990s. The use and sale of crack was concentrated among younger demographics and the within-group bias in day-to-day interaction may have limited the spillover of violence to others groups.

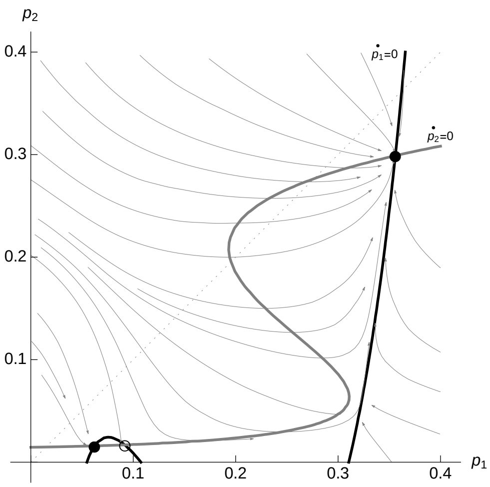
Two further observations are timely. First, a high-prevalence equilibrium is persistent. As shown above, a small increase of μ_{y1} from -0.9 to -0.89 may move the community to an equilibrium where guns are prevalent in *both* groups. Holding other parameters fixed, reverting to a low state in either group requires μ_{y1} to fall below -1.13, meaning that group 1 would value weapons less than group 2 on average. Securing such as preference reversal seems unlikely.

Second, the intensity of inter-group interactions plays a changing role. At a "low-low" equilibrium, inter-group interaction is a moderator and helps check group 1, who otherwise would have a high equilibrium carry rate. In Figure 13c, a decline in inter-group interaction eliminates the "low-low" equilibrium and triggers a run-up in gun prevalence in group 1 (Figure 13e). At a "high-low" equilibrium, however, a rise in inter-group interaction can cause contagion. This occurs in Figure 13. Starting from panels (e) or (f), an increase in δ will never revert to a "low-low" equilibrium. If δ rises to $\delta = 0.12$, the community will be on a path to a "high-high" equilibrium instead.

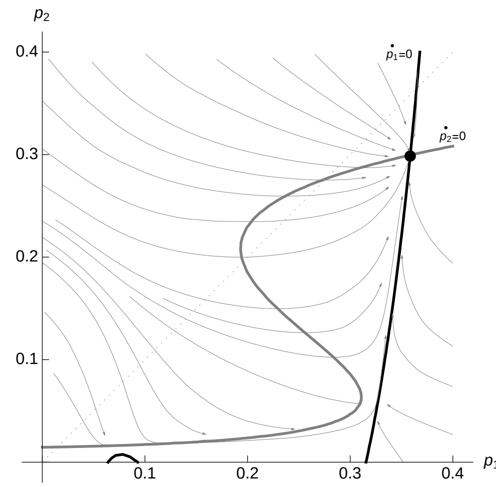
3.4 Misperception of Threat

It is common for many people to incorrectly perceive others' actions, especially if these are private and not easily verifiable like the decision to carry a gun. A preponderance of tragic media reports or ominous accounts from close acquaintances may lead to an overestimate of the aggregate danger and gun prevalence in the community (Hemenway et al., 2011). This overestimate may reinforce the persistence of gun violence if many people arm for protection given the perceived higher level of threat.

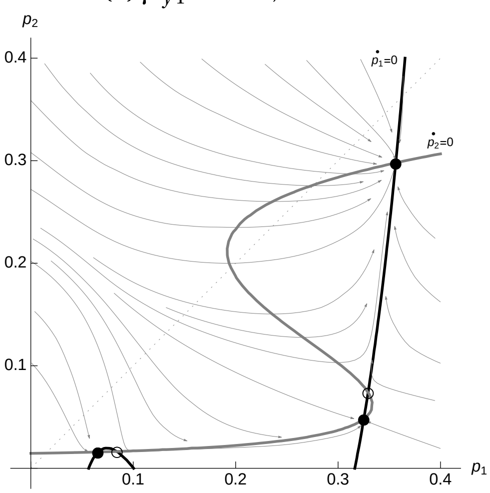
To better understand these effects, we can extend our original model to incorporate potentially miscalibrated beliefs. If p is the fraction of the population choosing to arm, we define



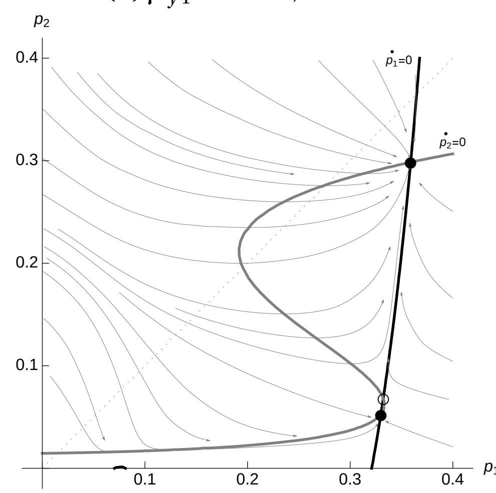
(a) $\mu_{y1} = -0.9$; $\delta = 0.12$.



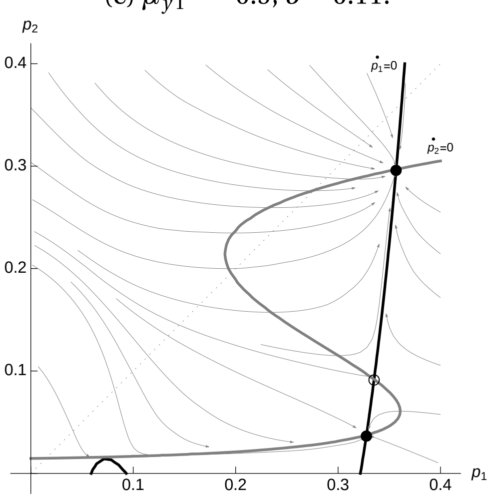
(b) $\mu_{y1} = -0.89$; $\delta = 0.12$.



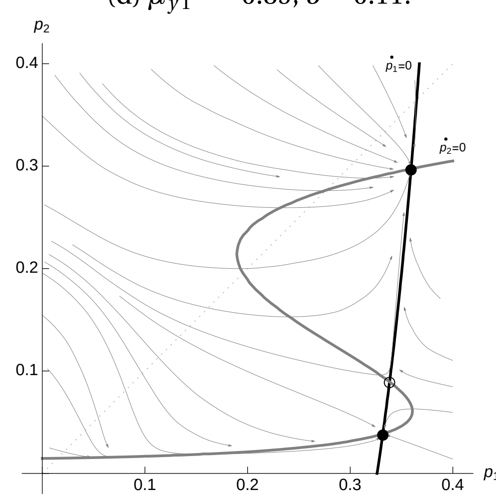
(c) $\mu_{y1} = -0.9$; $\delta = 0.11$.



(d) $\mu_{y1} = -0.89$; $\delta = 0.11$.



(e) $\mu_{y1} = -0.9$; $\delta = 0.1$.



(f) $\mu_{y1} = -0.89$; $\delta = 0.1$

Figure 13: Cases examined in Example 2 as a function of the average instrumental value of guns in group 1 (μ_{y1}) and inter-group interaction (δ).

the variable q as the perceived or estimated fraction doing so. Now, we can rewrite (6) as

$$\dot{p} = \gamma(q) - p. \tag{11}$$

In this expression, $\gamma(q)$ is the proportion of the population for whom g is optimal given the *belief* that fraction q of the population is armed. The fraction of the population choosing to arm will rise when $\gamma(q)$ exceeds p; it will fall when $\gamma(q)$ is less than p.

To model beliefs, posit a simple adjustment process:

$$\dot{q} = p^{1-\beta} - q. \tag{12}$$

This expression says that beliefs q will adjust toward $p^{1-\beta}$, a possibly biased estimate of the proportion choosing to arm. The parameter $\beta \leq 1$ measures the degree of bias. If $\beta = 0$, beliefs rational and q will converge to the true fraction choosing to arm p. If $\beta > 0$, people are prone to overestimation. Even if beliefs are initially correct ($q = p$), over time perceptions will exaggerate the level of threat since $\dot{q} = p^{1-\beta} - p > 0$.[22]

Together, (11) and (12) define a two-dimensional dynamic system. An equilibrium of this system is a pair of values (q^*, p^*)—a belief concerning the proportion choosing to arm and the actual proportion doing so, respectively—such that $\dot{q} = 0$ and $\dot{p} = 0$. There always exists at least one equilibrium, though in general there may be many.[23]

Figure 14 illustrates the possible consequences of misperception with increasing levels of bias. The perceived fraction choosing to arm q is measured on the horizontal axis, while the actual fraction doing so p is now on the vertical axis. The curve $\dot{p} = 0$ is the function $p = \gamma(q)$ while $\dot{q} = 0$ is the function $p = q^{1/1-\beta}$. Equilibria occur where these curves intersect. In panels (a)–(c), the function $\gamma(q)$ is held constant and $p = q^{1/1-\beta}$ changes to reflect increasing severity of overestimation. Since $\gamma(q)$ is nondecreasing, this is an instance of our model with strategic complementarities.

The following proposition identifies how equilibria change with small changes in peoples' bias β. In the presence of strategic complements, overestimates nudge an equilibrium to a higher level of armament. The converse is true in the case of strategic substitutes.

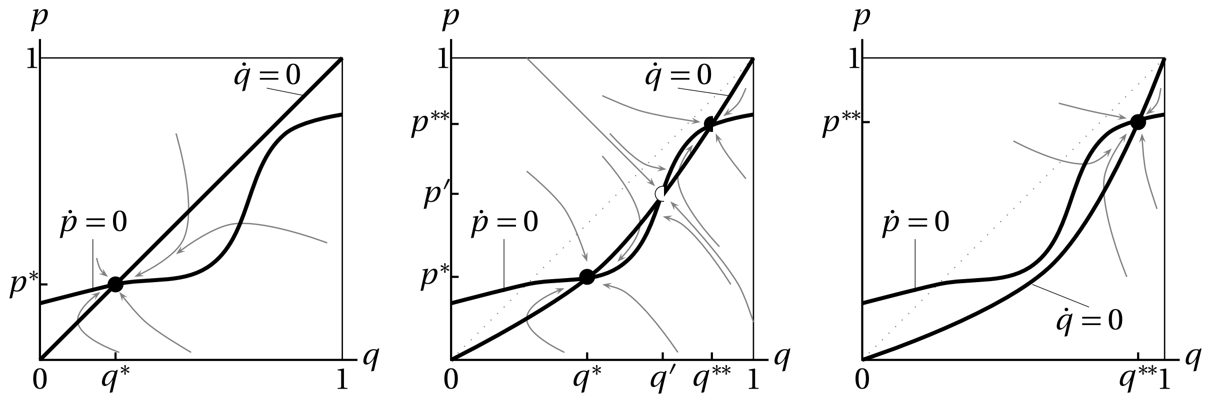
Proposition 4. *Suppose (q^*, p^*) is a regular equilibrium*[24] *and $\gamma(\cdot)$ is differentiable at q^*. If γ is increasing at q^*, then $dp^*/d\beta \geq 0$. Else, if γ is decreasing at q^*, then $dp^*/d\beta \leq 0$.*

Large changes in β may lead to significant transitions between equilibria. With rational beliefs, $\beta = 0$ and the curve $\dot{q} = 0$ reduces to $p = q$. Thus, an equilibrium occurs when $\gamma(q)$

[22] This is true except when $p = q = 0$ or $p = q = 1$. These are not relevant cases for our application.

[23] The function $\gamma_\beta(p) := \gamma(p^{1-\beta})$ is continuous and maps the unit interval to itself. Thus, it has a fixed point $p^* \in [0,1]$. Set $q^* = (p^*)^{1-\beta}$. The pair (q^*, p^*) is an equilibrium.

[24] Call (q^*, p^*) regular if the curves $\dot{q} = 0$ and $\dot{p} = 0$ are not tangent at (q^*, p^*).



(a) A low gun prevalence equilibrium (q^*, p^*) with rational beliefs.

(b) Multiple equilibria when gun prevalence is slightly overestimated.

(c) A high gun prevalence equilibrium (q^{**}, p^{**}) when prevalence is significantly overestimated.

Figure 14: An overestimate of the gun carry rate can transition the equilibrium from a low level, panel (a), to a high level, panel (c).

intersects the 45°-line, as shown in Figure 14a. This outcome is the same as in our baseline model. If β increases sufficiently, multiple equilibria arise. In Figure 14b, the low- and high-prevalence equilibria, (q^*, p^*) and (q^{**}, p^{**}) respectively, are both stable. (The third equilibrium, (q', p'), is a saddle point.) Finally, if β is relatively large, there is again a unique equilibrium, but only at a high level (Figure 14c). An interesting feature of this high equilibrium is that the degree of overestimation *at the equilibrium* is minor since the value of q^{**} and p^{**} are close together. However, this equilibrium is sustainable because overestimation is more severe when p is low or moderate. This makes equilibria a low levels unsustainable leading to an unravelling of beliefs and actions up to (q^{**}, p^{**}). This fact appears in Figure 14c as the large gap between the $\dot{q} = 0$ curve and the 45°-line (which defines rational beliefs) when q and p assume values in the middle of their range.

4 What are the Policy Options?

In this section, we combine the results of the theoretical model with what we know concerning previous evaluations of criminal justice policies to outline the likelihood of success and the costs associated with different efforts to reduce violence among young black males. The policies we consider can have some other positive consequences, such as a reduction in suicides, but we are defining success narrowly by focusing only on reductions in gun violence. In section 4.1, we discuss policies that at present have little empirical backing as a viable pathway to reduce violence among young black males.[25] In sections 4.2 and 4.3, we draw upon our model to address policies targeting the perceived protective benefits of a gun and the criminal value of a weapon.

4.1 Policies With Limited Empirical Support

An obvious response to the problem of gun violence among young black males is some form of gun control. The specifics of any gun control measure can vary along many dimensions such as what guns to cover, penalties for violations, or locus of enforcement (local, state, or federal). While the details matter, we believe the benefit of typical gun control policies are most likely limited in the near term for two key reasons.

First, most gun control policies only restrict the future production or sale of firearms and do not change the current stock. Currently, guns are plentiful in the US. In 2017 there were 393 million guns in the United States (Karp, 2018). As a result, policies that only alter the future sale or ownership of guns will most likely not alter the current stock and will have a negligible impact on homicides in the short run. A counterargument is the fact that many guns used in crime are "new." About one third of guns traced in crimes are under 2 years of age.[26] One reason is that criminals may prefer "clean" guns that are less likely used in a prior felony. Gun control efforts that decrease the flow of new guns may then have some impact on criminal behavior, but this impact would take some time to accrue.

Second, gun policies are hampered by their typical adoption at the state level and can be undone by cross-state gun sales. Knight (2013) shows that firearms tend to flow from states with weak gun laws to states with stricter provisions. For example, Illinois requires a 72-hour waiting period and background check for all gun purchases. Moreover, Chicago has an assault weapons ban and had a handgun ban that was later declared unconstitutional.[27] Despite these restrictions, Chicago has historically had one of the highest rates of gun violence. The murder rate in Cook county, which includes the city of Chicago, in 2020 was 18.7 (per 100,000 population) and the rate for young black males was 247. (The corresponding national averages are 7.4 and 104.3, respectively.) Chicago is very close to Wisconsin and Indiana, two states with much weaker laws. Cook et al. (2007) demonstrate that Chicago's handgun ban "was ineffective in reducing the prevalence of gun ownership in the city" (p. 590) and primarily increased transaction costs in associated underground markets.

[25] In many cases, we are not saying particular policies will not work. Rather, it is the case that currently, evidence of their benefit is lacking.

[26] Authors' calculations based on Bureau of Alcohol, Tobacco, Firearms and Explosives, *Firearms Trade Data - 2019*, accessed September 2, 2021, ⟨https://www.atf.gov/resource-center/firearms-trace-data-2019⟩.

[27] McDonald v. City of Chicago, 561 U.S. 742 (2010).

The problems of interstate gun markets can be bypassed by federal legislation. The US has little experience with strong federal legislation and what has been passed at this level has had minimal impact. For example, the Brady Handgun Prevention Act of 1994 required gun dealers with a federal firearms license to perform background checks. As some states had Brady-type laws already, Ludwig and Cook (2000) used the variation in the timing of laws across states to demonstrate that the law had no impact on homicides but did reduce suicides among those aged 55 and above. This does not mean federal legislation will be ineffective, it is just that there is little evidence to date of an effective federal program.

A comprehensive review of the research on gun control is beyond the scope of this paper. A recent summary by Smart et al. (2020) concluded that the only laws with conclusive evidence of an impact are child-access prevention laws, that reduce gun injuries and unintended deaths among children, and "stand your ground" laws, that increase firearm homicides. For most gun laws, they concluded that "[w]ith a few exceptions, there is a surprisingly limited base of rigorous scientific evidence concerning the effects of many commonly discussed gun policies."

There is considerable controversy over whether right-to-carry laws reduce crime. Lott and Mustard (1997) argued that gun ownership deters crime and present evidence that these laws reduce homicides. Black and Nagin (1998) and Donohue (2004) call into question the original results. The controversy over the research is covered extensively by National Research Council (2005). Formally, our model does not preclude the possibility that guns have a deterrent value. At times, the function $\gamma(p)$ may be decreasing, which captures this effect. However, Proposition 2 suggests a deterrent effect, if any, is most probable at equilibria with a low gun prevalence. This seems unlikely as the appropriate departure point given our focus on young black males. Even if we were to grant that the original empirical work in this area was correct, it is hard to use the results in Lott and Mustard (1997) to justify this as a policy strategy in this context. The data cited in section 2 suggest that young black males have not needed legal standing to carry weapons in practice and there is no shortage of guns in this population.

Buyback programs can reduce the stock of guns. An example was Australia's National Firearms Agreement (NFA), wherein the government purchased an estimated 20 percent of the country's guns (Reuter and Mouzos, 2003). Leigh and Neill (2010) found that the NFA produced statistically significant reductions in gun suicides but inconsistent results on gun homicides. In a review, Ramchand and Saunders (2021) concluded that the "evidence is weak for an effect of the NFA on firearm homicides." Buyback programs have been less successful in the US. Using county-level data, Ferrazares et al. (2021) examined the impact of 339 gun buyback programs in the US from 1991 to 2015. They found no evidence that these programs reduced either gun suicides or homicides.

McDowall et al. (1992) argue that sentence enhancements for gun crimes are the most popular policy for addressing gun violence. By 2012, 25 states had sentence enhancements for gun crimes (Abrams, 2012). The evidence on the impact of sentence enhancements is at best conflicted. MacDonald et al. (2016) examined murders before and after sentence enhancements in six cities. They found enhancements reduced murders but not gun robberies. However, when they pool data across all six cities, there is no statistically significant impact of enhancements on murders. These results are difficult to interpret as there was no control group in the analysis. Abrams (2012) used the variation across states in the timing of sentence enhancements and found enhancements reduced gun robberies but had no impact on violent crimes such as rape, murder and assaults. This conclusion is similar to that of Marvell and Moody (1995) who found sentence enhancements had no impact on homicides.

4.2 Policies Designed to Reduce the Protective Value of Guns

Recall that in our model, persons varied along two dimensions—the intrinsic protective and instrumental value they ascribe to firearms. Sufficient reductions in these values can move the population to a low gun equilibrium. Fontaine et al. (2018) asked youths on Chicago's South Side about the ways to reduce gun violence. They conclude that the "reasons for gun carrying among young adults should be understood as an interplay between their perceptions of threat to self and family/friends and their perceptions that they need to carry because everyone else is carrying" (p. 11). These rationales concern the protective value of guns. They combine beliefs about others' actions and the appropriate behavior given those beliefs.

For teens and young adults, gun carry rates rise with the perceived level of gun carry rates among peers and neighbors (Hemenway et al., 2011; Bailey et al., 1997; Sheley et al., 1992; Williams et al., 2002). These perceptions may be inaccurate. In a survey of Boston youth, Hemenway et al. (2011) found that carry rates are strongly predicted by one's perception of other people's carry rates, but that youths tend to vastly overstate this latter number.

The model of section 3.4 shows the limits of the "information channel" for addressing the problem. One strategy directly targets beliefs regarding others' actions, the variable q in the model of section 3.4. If the true carry rate is overestimated, an information intervention (e.g., media campaigns, educational programs, etc.) may be able to dislodge a high-carry equilibrium and set a course to one with a low carry rate. To see how, consider the case in Figure 14b and suppose the community is at the high-carry equilibrium (q^{**}, p^{**}). If beliefs are reset to some $\hat{q} < q^{**}$ so that $(\hat{q}, p^{**})$ is the basin of attraction of the low-carry equilibrium (q^{*}, p^{*}), the outcome will converge to the lower level.

Two complications hamper this strategy. First, it works only if there are multiple equilibria, which may not be true. Second, it is often insufficient to only convey the truth. In Figure 14b, nudging beliefs down to the true carry rate at the high-gun equilibrium, $\hat{q} = p^{**}$, leads to an eventual return to the high-gun equilibrium at (q^{**}, p^{**}). In fact, $\hat{q}$ must be *much* lower to be effective. This necessity for deception makes it a flawed strategy.

A second approach is indirect and targets the perception bias, the parameter β in the model of section 3.4. Proposition 4 implies that small reductions in β can reduce the equilibrium carry rate when actions are strategic complements near the equilibrium. And, a dramatic shift in equilibrium outcome is possible when changes in β are large. To the extent this parameter can be affected by policy, it is likely to be so only in the long run through improved education or other socioeconomic advances. (These changes would also impact preferences, independent of their influence via the belief channel.) Overall, however, changing perceptions about the gun carry rate remains an untested strategy.

The alternative to changing beliefs is to affect the preferred action despite others' possible decision to arm. Such policies would shift the distribution of $\tilde{x}_i$ and are easily examined in the normal model (section 3.1) as a reduction of the parameter μ_x. A natural strategy is to improve community safety, thereby reducing the perceived protective benefit of being armed. Studies have shown that exogenous increases in the size of local police forces reduce murders (Levitt, 1997; Evans and Owens, 2007; Chalfin and McCrary, 2018; Mello, 2019). These papers use aggregate mortality rates as the outcome of interest and do not examine the impact on rates for specific groups like young black males. Three of these papers found homicide/police elasticities of around −1. Chalfin et al. (2021a) found the homicide/police elasticity was substantially larger for black murder rates than for whites.

Despite the existing evidence, an expanded police force does not seem to be a viable strategy. If the effects are as large as estimated, even a massive increase in the size of the police force of 25 percent would not bring rates for young black males anywhere near the rates for young white males. Furthermore, large changes in the police force seem unlikely given the current political climate. The number of officers per 1,000 people in the US has fallen slightly from 2.5 in 1999 to 2.4 in 2019.[28]

Maybe the most far-reaching effort to improve public safety, with a focus on gun crime, was conducted in New York City. The election of mayor Rudi Guilliani in 1994 and his installment

[28]Federal Bureau of Investigation, "Crime Data Explorer: Police Employment," accessed September 3, 2021, ⟨https://crime-data-explorer.app.cloud.gov/pages/le/pe⟩.

of William Bratton as the Police Commissioner ushered in a set of sweeping police reforms. See White (2014) for a review. Among them was a focus on "getting guns off the streets" and an initiative with that name was started. In the first three years of the program, 50,000 guns were confiscated (Wintemute, 2005).

An element of the program was the controversial policy of stop, question, and frisk (SQF). SQF is typically a reactive policing policy where officers respond to potential offenses that have been reported. In New York, SQF was more aggressive and proactive. At its peak, SQF lead to so few arrests there were questions about the probable cause officers were using to justify stops.[29] Apel (2016) notes that "an intentional by-product of the use of the SQF tactic was the removal of handguns from the street. Indeed, an important legal justification for SQF is the personal safety of police officers" (p. 59). SQF was expanded and altered over time. The biggest change came in 2004 when the city started Operation Impact that deployed extra police and more SQF in high crime areas (MacDonald et al., 2016).

In relation to our analysis, SQF is interesting to consider for a variety of reasons. First, SQF is extensive.[30] Stops increased from 161,000 in 2003 to almost 700,000 in 2011—a rate of about 8,500 per 100,000 population. A rapid decline to around 45,000 SQF incidents occurred after 2011 following the filing of a lawsuit against the city for the practice. The suit was decided in federal court in 2013 against the city.[31] The judge ruled that the police violated the Fourth Amendment by conducting unreasonable searches and the Fourteenth Amendment by conducting stops in a discriminatory manner.

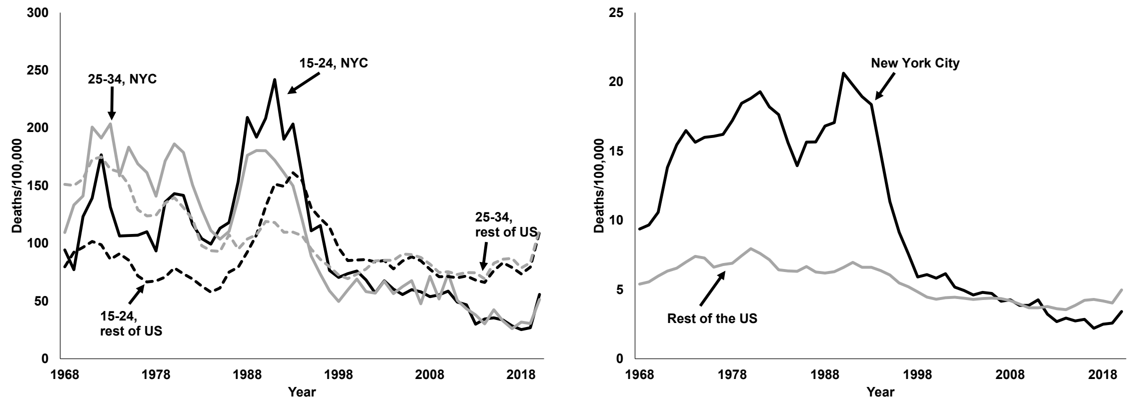
Second, SQF stops were primarily directed towards the subject of this paper, young black males. Black males ages 15–34 are 3.5 percent of New York City's population, but they were roughly one-third of stops. From 2003 through 2012, the stop rate of young black males was a staggering 75,000/100,000.[32] During this time there were 1.1 million stops of young black males. Of these stops, 5 percent led to arrests, 1.5 percent uncovered contraband, and 0.2 percent uncovered a weapon.

[29] William Bratton, the architect of SQF, acknowledged that in the earlier days of SQF only 6 percent of stops lead to arrests (Bratton and Kelling, 2015).

[30] Data on SQF incidents starting in 2003 is available for download: New York Police Department, "Stop, Question and Frisk Data," accessed September 3, 2021, ⟨https://www1.nyc.gov/site/nypd/stats/reports-analysis/stopfrisk.page⟩.

[31] Floyd, et al. v. City of New York, et al., 959 F. Supp. 2nd 540 (S.D.N.Y. 2013).

[32] Many papers examine the disparate impact of SQF on minority populations. The raw data shows minorities are stopped much more than whites, but two key empirical questions are whether individuals were stopped in proportion to their groups' engagement in crime and how the yield from stops varied by race. Papers that address these questions, but get conflicting results, include Gelman et al. (2007), Ridgeway (2007), Goel et al. (2016), and Coviello and Persico (2015).



(a) Black males, ages 15–24 and 25–34.

(b) Everyone not a black male, ages 15–34.

Figure 15: Murder rates for New York City and the rest of the United States by demographic subgroups, 1968–2020, CDC Wonder Data.

Third, during the height of SQF use in New York City, murders of young black males fell dramatically. In Figure 15a, we report in solid lines the murder rate for black males 15–24 and 25–34 from New York City while the dotted lines of the same color represent the same numbers for the rest of the country. The police reforms that started in New York City in 1994 occur at a time when the crack epidemic was receding and murder rates for young black males were falling. This makes it difficult to assign how much of the decline is due to SQF or other factors, like mean reversion. That said, the rates for young black males in the rest of the country retreat to their pre-crack levels and do not decline, whereas the decline is dramatic in New York City. In Figure 15b, we report the time series of murder rates in New York City and the rest of the country for everyone who is not a black male 15–34. Here, there is conflicting data on the impact of the SQF program. A result consistent with those favorable to SQF is that New York City had persistently higher murder rates than the rest of the country and starting in 1994, these murder rates drop quickly and are now below the rest of the country. The percent drop in murder rates in New York City for those that are not black males 15–34 is comparable to the drop for younger black males, the primary targets of SQF. This could mean some other policy was impacting murder rates.

The academic literature on the impact of SQF in New York City is not definitive. Rosenfeld and Fornango (2014) found SQF had no impact on robbery and burglary while Weisburd et al. (2016) found negative impacts on aggregate crime. Furthermore, as Apel (2016) notes, SQF was but one policy introduced over this period so it is difficult to disentangle its impact from other reforms. Maybe most importantly, no one has examined the impact of SQF on murders of the prime targets of SQF, younger black males. A recent review concludes that SQF programs implemented as citywide crime control strategies have produced “mixed results” (National Academies of Sciences, Engineering, and Medicine, 2018, p. 150).

The costs of the SQF policy is significant and multifaceted. The SQF policy had negative impacts on the relationship between minority communities and the police (e.g., see studies reviewed in Fagan et al., 2016; National Academies of Sciences, Engineering, and Medicine, 2018). As perceptions of legitimacy decline, citizens cooperate less with the police, such as reporting crime (La Vigne et al., 2012). Aggressive SQF policies can also have negative consequences on citizen well being, adversely affecting mental health (see, e.g., Geller et al., 2014; Sewell et al., 2016) and school test scores (Legewie et al., 2019).

The model developed in section 3 suggests that once a high-gun carry equilibrium is obtained, it would take a massive reduction in the protective value of guns to return the world to a low gun equilibrium. There may have been no more targeted policing strategy for gun violence among young black males that SQF in New York City. The numbers above suggest it was especially targeted to young black males, but the low yield of arrests, guns and contraband suggest the program was not targeted to likely criminals but to a much larger group. The increased risk of sanction for carrying a weapon along with improved in community safety reduce the attractiveness of guns as a protective means to non-criminals. If we were to make the generous assumption that all of the decline in murders in New York City were attributable to SQF, then this program illustrates the degree to which jurisdictions must police in order to obtain large reduction in the protective value of guns and hence a large reduction in murders. This conclusion is consistent with the relative rigidity of equilibria with respect to changes in μ_x. Large and costly interventions along this dimension are necessary to shift outcomes.

Narrower interventions affecting preferences and safety may be effective, though their impact will be less far reaching. A program that has been shown to reduce mortality from homicides for youths is summer employment. Gelber et al. (2016) show that having a summer job reduces mortality by about 18 percent and about half of that decline is from a reduction in homicides. The authors suggest this is likely due to incapacitation where youths are kept out of dangerous situations through work. This suggests that activities that take at-risk youths out of their current environment and into safer situations may have some benefits in reducing homicides. These benefits may extend well past program participation. Heller (2014) found summer employment in Chicago reduced arrests for violent crime by 43 percent and declines persisting up to 16 months after program participation. This suggests that benefits may not be due solely to incapacitation. These effects are consistent with our analysis from section 3.3 wherein changing the pattern of interaction among at-risk groups can moderate outcomes.

4.3 Policies Designed to Reduce the Criminal Value of Weapons

A reduction in the criminal value of weapons, the parameter μ_y in the normal model, affects gun carry rates directly and indirectly through the equilibrium response of persons arming for defensive reasons. There may be a number of successful interventions that can be pursued along these lines, each with different costs.

A policy that has showed some promise is labeled "pulling levers." This strategy was originally proposed by Kennedy (1996); see Braga and Weisburd (2012) for a review. It is a focused deterrence strategy where local police use a menu of sanctions ("pulling levers") to address a particular criminal activity. The police enforcement activities are targeted to particular offenders that are thought to be the catalyst of the identified problem.

The first example of this strategy was Boston's Operation Ceasefire. It was designed to reduce gun violence among youths. The effort had two components. The first was to prevent the diversion of legal retail guns into illegal markets. The second was to reduce violence among gang members. Analysis by a working group of community organizations, academics, and the police determined that youth violence was driven in part by the high gun carry rates among youths not involved in criminal activity who were carrying guns for protection. They also determined that a small number of violent offenders, who were also gang members, drove much of the violence that youths feared. The local authorities produced a large-scale crackdown on gang activity, including non-violent offenses. The gangs were told directly that if the violence was reduced, the efforts against the gang's non-violent activities would be relaxed. The goal was to reduce the external events that lead most youths to carry guns for protective purposes. Braga et al. (2017) and Braga and Pierce (2005) argue that Operation Ceasefire was successful at reducing youth gun violence.

Pulling levers programs have been attempted in other cities, including Indianapolis, Stockton, Cincinnati, and Nashville. A review by Braga and Weisburd (2012) suggests that this strategy appears to be effective, but its assessment has been limited to observational studies. We are unaware of randomized control trials (RCT) of this approach.

A second group of policies is "hot spot" policing where law enforcement resources are directed to areas with concentrated crime. This policing strategy has been the subject of RCTs and quasi-experimental evaluations. A review by Braga et al. (2014) concluded that these interventions generated "small but noteworthy reductions" (p. 633) in crime. Two criticisms of hot spot policing are that the gains are short-term and that the crime returns once the police reduce their presence in the hot spot (Rosenbaum, 2006). The Philadelphia Foot Patrol Experiment achieved large short-term declines in crime with increased foot patrols in more violent areas (Ratcliffe et al., 2011) but no long-term change in crime in these same areas (Sorg et al., 2013).

Hot spot strategies can be understood within our model either as a temporary reduction in μ_y or as a discrete reduction of the carry rate p below its (original) equilibrium value. The former induces a gradual shift by affecting (criminals') preferences while the later is a discrete shock to the state of the immediate area (e.g., through high arrest rates). As in the case of information interventions (see above), a permanent transition to a low-carry equilibrium is possible under certain circumstances. For example, in Figure 12a $\mu_y = -0.9$ and a temporary reduction to $\hat{\mu}_y = -1.1$ (Figure 12c) annihilates the high-carry equilibrium. Provided this intervention lasts sufficiently long for the community to converge close to the low-carry equilibrium, it will stay near that level thereafter, as long as μ_y does not subsequently rebound too far once the intervention is curtailed. Likewise, if in Figure 12a the carry rate is reduced from the high-equilibrium of $p^* = 0.27$ to some $\hat{p} < 0.10$, the community will thereafter converge to and remain at the low-prevalence equilibrium. That such outcomes appear elusive in practice suggests that either the initial conditions were not conducive or that the interventions lacked the duration and magnitude to be successful.

An understudied success story is the decline of gun violence in Los Angeles. In 1968, the murder rate of young black males in Los Angeles county (105/100,000) was slightly higher than the rate in New York City (94). Murder rates for this group peak in Los Angeles county at 314 in 1994 and have fallen to 47 in 2020, a decline of 85 percent. This is similar in relative terms to the decline in New York City (down from a peak of 242 in 1991 to 26 in 2019 for an 89 percent decline). While New York City has been the subject of many studies, there is little work on Los Angeles. Two exceptions are Grogger (2002) and Ridgeway et al. (2019) who examined the impact of gang injunctions in Los Angeles.

A gang injunction is a civil abatement order that restricts specific gang members activities within defined geographic areas. The terms of the injunctions are usually restrictions on lawful behavior and are designed to reduce gang influence in particular areas. These restrictions could include the prohibition on wearing gang colors, restrictions on association with other gang members in certain situations, or prohibiting the possession of drugs or the consumption of alcohol in public. Violations of gang injunctions mean gang members are subject to fines or imprisonment. Although not classified as such, gang injunctions possess characteristics of both pulling levers and hot spot policing. The Los Angeles City Attorneys Office has successfully filed 46 gang injunctions against 79 different gangs. Ridgeway et al. (2019) found that gang injunctions reduced homicides by 50 percent over the long run.

Gang injunctions have come under court scrutiny for two reasons. First, the restrictions are argued to violate the First Amendment right to association. Second, gang members have no due process to contest their identification as a gang member. In late 2020, the Los Angeles Police Department reached a settlement in a class-action lawsuit that allows individuals to contest their classification as a gang member.[33]

Recent work by Chalfin et al. (2021b) examined gang takedowns in New York City. These operations are highly targeted raids and arrests of specific gang members, often those operating in public housing with a high levels of violence. Although results for homicides are typically only statistically significant at the 10 percent level, the authors found that gang takedowns reduced homicides by 50 to 60 percent.

These two interventions have easily the largest estimated changes in homicides among the interventions listed above. These two are also the most targeted in both geography and at the individual level. In that way, they are the most focused on reducing μ_y.

Finally, work by Heller et al. (2017) using cognitive behavioral therapy (CBT) to encourage youths in Chicago to not resort to violence in possibly volatile situations has shown tremendous promise in reducing violent crime participation among at-risk youths. An on-going experiment, also in Chicago, provides six months of wrap-around services and trauma-informed CBT finds reductions in arrests for violent offenses by 43 percent (University of Chicago Crime and Education Labs, 2020).

5 Conclusion

The situation described in the empirical section above is bleak. The gun violence that surrounds young black males is devastating. In a period where gun violence was declining for nearly all subgroups, the violence for this segment of the population is high and appears to be stubbornly difficult to change. These facts are echoed in our model in that once a high-gun carry equilibrium is achieved, it is hard to move back to the low gun equilibrium.

As our discussion in the previous section illustrates, exiting this bad equilibrium is difficult. There have been some success stories, with New York and Los Angeles being two. Their success also illustrates a key prediction of our model, that reducing gun violence is easier by reducing the instrumental value of guns for criminals rather than the protective value for non-

[33] James Queally, "Los Angeles must change use of gang injunctions under court settlement," *Los Angeles Times* (online), December 26, 2020 (accessed September 3, 2021), ⟨https://www.latimes.com/california/story/2020-12-26/los-angeles-gang-injunctions-must-change⟩.

criminals. Although the evidence is not conclusive that stop, question, and frisk caused the decline in crime in New York, the costs were enormous and indicate the scale of a program that may be necessary if one were to attack the protective value of a gun. In contrast, gang takedowns in New York and gang interventions in Los Angeles have both been shown to reduce gun violence through attaching the instrumental value of carrying a gun. One caveat to these success stories is that the strategies employed by both cities have raised serious questions about the consequences for individual liberties, an important question that needs to be considered in any evaluation of the policies.

Unfortunately, the situation is getting worse before it gets better. The homicide rate has ballooned as the COVID-19 pandemic has progressed. In Figure 1, we showed that murder rates increased by 27 percent from 2019 to 2020. Much of this was due to an increase in gun murders, which rose 34 percent compared to 9.4 percent for non-gun murders. Many urban counties have experienced substantially larger increases including Jefferson County, KY, home to Louisville (81.3 percent), Milwaukee County, WI (72.3 percent), Alameda County, CA, home to Oakland (65.2 percent), and Orleans Parish, LA, home to New Orleans (64.2 percent), just to name a few. The groups with the highest murder rates already also had the greatest change in murder rates between 2019 and 2020. Breaking the population into three age groups (15–24, 25–34, 35 and up), four races (white, black, Asian/Pacific Islander, American Indian/Alaskan Native) and 2 genders, there are 24 groups. The three groups that saw the biggest increase in murder rates were white males 15–24 (36.0 percent), black males 25–34 (38.2 percent), and black males 15-24 (39.7 percent). The preliminary data for 2021 looks even worse. Murder counts for the first six months of 2021 are up 13.9 percent over the same time period in 2020.

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