# Peaceable Kingdoms and War Zones
Preemption, Ballistics, and Murder in Newark

Brendan O'Flaherty and Rajiv Sethi

"If I had not put an end to him today, he would have killed me tomorrow."[1]

## 9.1    Introduction

In 2006, 105 people were murdered in Newark, New Jersey, almost twice as many as were killed in 2000. If murders occurred in Newark at the national rate, there would have been sixteen. Using standard measures of the value of a statistical life, this implies a loss of $445 to $623 million from excess murders in Newark in 2006.[2] The entire cost of running city government was firmly in that range. Furthermore, while the increase in murder can be attributed almost entirely to an increase in gunshot homicides, the overall incidence of shooting incidents did not rise appreciably. What happened was a dramatic increase in *lethality:* far more shootings resulted in victim death.

1. Grace Doyle of Chicago, July 3, 1899, explaining why she shot her husband Timothy (quoted in Adler 2006, 101).

2. Aldy and Viscusi (2003) is a definitive reference on this topic. Levitt and Venkatesh (2000) estimate that young gang members in Chicago act as if they value their lives at much lower rates—an order of magnitude or two lower. Because these estimates are so far below the norm in this huge literature, perhaps some of the standard assumptions do not hold—the decision makers may not be aware of true probabilities, for instance, or their outside opportunities may

Why are so many people killed in Newark? Why did murders rise so sharply from 2000 to 2006? Why did the increase come about through greater lethality rather than more frequent shooting? What can be done to reduce the killing? And, more generally, what changes in fundamentals trigger changes in lethality and the incidence of murder, and how does the mechanism operate? We address these questions by developing a theoretical model of murder that is relevant not only to Newark, but also to other areas with high and volatile murder rates, including many cities in Latin America.

Murder differs from other serious crimes in several important respects. To begin with, murder is defined in part by a medical condition—clinical death—and random chance plays a major role in determining whether attempts at killing end up becoming murders. Second, murder admits a much wider array of motives than most other crimes, including jealousy, rage, paranoia, vengeance, and greed. Third, even in the absence of any legal sanction for murder, ordinary people under normal circumstances would gain little from taking the life of another. This is clearly not the case for crimes such as robbery or theft.

Fourth, murder is extremely serious. Most individuals value life more than they value large amounts of money and are willing to pay substantial sums to avoid even small increases in the risk of death. The average murder results in welfare losses estimated to be at least 5,000 times as large as the losses from the average robbery (Aldy and Viscusi 2003). Hence, people are willing to take drastic steps to avoid being killed, and these steps may include *the preemptive killing of others.* Our simplest answer then to the question of why people kill so often in Newark is that they kill to avoid being killed. Other motives are present, to be sure, but huge deviations from national norms can be sustained only if a significant proportion of murders are motivated by self-protection. Some Newark streets are sometimes described as a war zone, and in war, too, soldiers kill to save their lives and those of their comrades.

More precisely, the decision to kill is characterized by strategic complementarity: an increase in the likelihood of being killed by someone raises the incentives to kill them first.[3] Under such circumstances it is possible for expectations of high murder rates to become self-fulfilling: murders beget murders. Furthermore, small changes in fundamentals can, under certain circumstances, induce large changes in the equilibrium murder rate. We show how this can happen as a result of a dramatic change in the choice of lethal-

---

not be accurately modeled. Many Newark murder victims resemble the young gang members studied by Levitt and Venkatesh, but many do not.

3. Thus, our story is an example of the social multiplier discussed in Goldin and Katz (2002) and Glaeser, Sacerdote, and Scheinkman (2003). Rasmusen (1996) and Schrag and Scotchmer (1997) also develop models where increases in criminal activity are self-reinforcing, but their analyses deal with crime in general rather than murder in particular and are, therefore, based on different mechanisms (employer stereotypes and judicial errors, respectively). These mechanisms seem better at explaining long-run differences across communities than at explaining rapid changes in a particular community.

ity so that murders increase even as shootings remain relatively stable. We believe that this is what happened in Newark in the early years of this century. While we cannot identify any single trigger, several changes occurred that may have been enough to shift the equilibrium drastically: the prosecutor's office fell into disarray, the number of prisoners decreased, the police department withered, and the corrections department reorganized state prisons in a way that facilitated networking among gang members. Taken together, the impact of these changes was to drive expectations beyond a tipping point, resulting in a cascade of killings motivated in part by self-protection.

Our model is useful prospectively as well. How can Newark's murders be cut? The obvious answer is to improve fundamentals—for instance, by investing in high quality professional police work that increases the probability that murderers will be apprehended and convicted. Once a high murder regime has been entered, however, it cannot be escaped simply by restoring fundamentals to their initial values. According to our analysis, the corrective changes that are required in order shift expectations of murder rates back down to earlier levels may be much greater in magnitude than the changes that triggered the rise in the first place. The analysis also tells us what sorts of public relations efforts to mount and which to avoid. More speculatively, we look at ideas like multiple classes of liquor licenses and other efforts to quarantine the contagion of violence. A clear implication of the model is that murders will decline in a manner that is as sharp and sudden as the increase has been. In fact, it may be the case that such a collapse in the murder rate is already underway: in early 2008, Newark went over forty days without a single murder, the longest recorded spell without a murder in the history of the city.

The idea that two armed individuals may choose to shoot at each other simply out of fear that they may be shot first dates back at least to Schelling (1960). Even when both parties to a potential conflict prefer that no violence occurs, uncertainty about the motives or intentions of others can result in mutual aggression. This process has been modelled formally as a coordination game with incomplete information by Baliga and Sjöström (2004), who identify conditions under which there is a unique (Bayes-Nash) equilibrium in which both players attack with certainty.[4] We build on this work by introducing the possibility that individuals face not just the option of violence but also a choice of lethality, where greater lethality must be purchased at some cost. This allows us to explore how equilibrium levels of lethality and

---

4. This happens because there is some proportion, possibly very small, of individuals for whom aggression is a dominant strategy. The presence of such types places a lower bound on the likelihood of being attacked, which induces some individuals for whom aggression is *not* a dominant strategy to also attack. Applying this reasoning iteratively, one can see that peace may be impossible to support in equilibrium provided the distribution of the costs of aggression does not rise too steeply. Baliga and Sjöström explore the possibility that cheap talk could allow the parties to coordinate on the peaceful outcome. Basu (2006) applies a variant of this model to examine racial conflict, and Baliga, Lucca, and Sjöström (2007) extend it to study the manner in which political institutions affect the likelihood of war.

murder covary with the underlying parameters of interest. For instance, one implication of our model is that a deterioration in fundamentals causes murders to rise more rapidly than shootings, so the ratio of shootings to murders declines.[5] This is consistent with the Newark data.

In related work, Gaviria (2000) tries to understand an episode of sharply increasing murder (in Colombia from the early 1970s to the early 1990s) and uses a model of strategic complementarity to explain why the increase was so sharp. The sources of strategic complementarity are quite different from those considered here: instead of preemptive escalation, Gaviria emphasizes congestion in law enforcement, gun diffusion, and cultural changes. We do not believe that these latter mechanisms were operative to an important degree in Newark and will explain why in the sequel. Along similar lines, Blumstein, Rivara, and Rosenfeld (2000) look at the rise in youth homicide in the United States in the late 1980s and attribute it to changes in the drug market that led to the diffusion of guns. Their model also (implicitly) emphasizes contagion among gun-bearers and potential murderers. Again, we do not think that gun-diffusion was a particularly important part of the Newark story. Our model of preemption, we believe, is more widely relevant in the sense that preemption could have played a significant role in both the Colombian episode and that in the United States in the 1980s.

The plan of the chapter is the following. We begin by describing the time trend of murders in Newark and in the nation as a whole. Newark's time trend is unusual (though not unique) within the nation but not unusual within New Jersey. This tells us that we cannot simply appeal to national trends to explain what is happening—nor do Newark officials have to wait for national trends to right themselves. Section 9.3 is about the mechanics of murder in Newark. Demographically, the rise is confined almost exclusively to African American men but not confined by time or premises. Gunshot wounds are entirely responsible for the rise but not because there were more shootings. The primary story is that shootings became more lethal, and they did so on many dimensions—more multiple shot incidents, more high-caliber weapons, and more just plain accuracy. Section 9.4 presents our model and shows some of the correspondence with Newark data. Section 9.5 reviews some of the existing empirical literature in economics on murder and shows how our model is consistent with this literature. We concentrate on arrest rates, incarceration, and police strength. At first glance, murder appears nowhere near as responsive to fundamentals as our model indicates it should be in many cities, but we show several reasons why many of the papers we review would miss the responsiveness in situations like Newark's.

Next, in section 9.6, we look at the possible changes in fundamentals that could have driven the increase we observe. Upper-bound estimates on the

---

5. In fact, we show that it is theoretically possible for shootings to decline in absolute terms even as murders rise.

three fundamentals account for a large part of the rise in murder in Newark, and we think that strategic complementarity can explain much of the rest. We review witness intimidation and show how it complements the answers we are proposing. We also show why many New Jersey cities experienced the same rise in murder that Newark did at about the same time. On the other hand, we argue that interjurisdictional spillovers and changes in the drug and gun markets and in the macroeconomy explain little of the trend in Newark. Finally, in section 9.7, we turn to policy. We look at the three most famous incidents of murder reduction (Boston, Richmond, and New York City), critically review the literature on whether the associated programs actually caused the reductions, and draw implications for the city of Newark. The second half of section 9.7 presents our tentative recommendations for Newark, and section 9.8 concludes.

## 9.2    Murder Trends

Figure 9.1 compares the murder rate in Newark since 1977 with the national rate. To make the two series comparable, we set their 2000 values equal to 100. Both series peak in the 1980 and fall until around 2000. (Newark's trough is actually 1997, but the number of murders in 1997 is only two different from the number in 2000.) The fall in Newark murders is more precipitous than the fall in national murders and does not seem to be interrupted by the crack epidemic, unlike the national series. As expected, murders in Newark fluctuate more than the aggregate for the nation as a whole although the two series track each other quite closely until 2000. After that, the picture changes. The national series stays essentially flat, but Newark rises. By 2005, which is approximately the same as 2006, Newark murders have returned to their late-1980s, early-1990s level: below the peak but substantially above the trough. Newark has also sustained this level for several years.

The increase in murders that Newark experienced is not a national phenomenon or even a national urban phenomenon. Among large cities, only a few are like Newark. Figure 9.2 shows the percentage change in murders for the ten largest cities, and all other cities with at least 100,000 African American residents in 2000. The comparison is between the geometric mean of 1998 and 1999 murders and the geometric mean of 2005 and 2006 murders.[6] Clearly, there was no general increase in murder in big cities during this period. Eleven cities experienced decreases, and only four saw a bigger increase than Newark. Hence, one cannot appeal to national phenomena, or even to national urban phenomena, to explain what has been happening there. In particular, explanations appealing to popular music, cell phone

6. We use two years to smooth out some noise, and we use the geometric mean because we are interested in percentage changes. The 1999 data are not available for Baltimore, and the 1998 data are not available for Cincinnati. In these cases, we use just the one available year (our source is the FBI, Uniform Crime Reports).

**Fig. 9.1    Newark and U.S. murder rates, 1977–2006 (2000 rate = 100)**
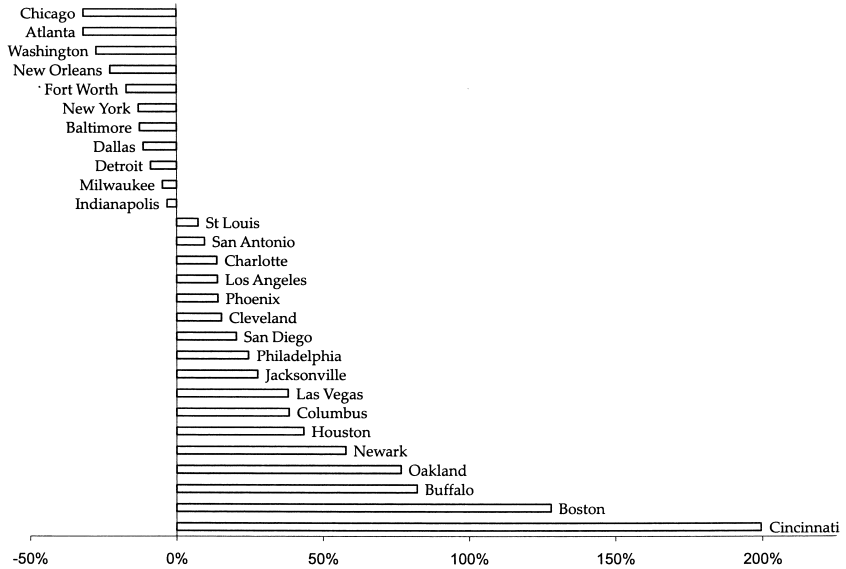


**Fig. 9.2    Percentage change in murders, 1998–1999 to 2005–2006, large cities**

| Table 9.1 | Percentage increase in murders, 1998–1999 to 2005–2006, New Jersey cities | |
|---|---|---|
| | East Orange | –2.3 |
| | Paterson | 16.5 |
| | Camden | 26.7 |
| | Newark | 57.7 |
| | Jersey City | 74.4 |
| | Elizabeth | 100.3 |
| | Trenton | 115.6 |
| | Irvington | 155.6 |

usage, or culture in general are sharply contradicted by figure 9.2. The discordance between Newark and New York City, which is just a few miles away and is part of the same media market, is especially strong.

The rise in murders appears to be a *New Jersey* urban trend, not a national urban trend. Murders in most other New Jersey cities rose as fast as they did in Newark or faster. Murders did not rise quickly in New Jersey outside these cities. Table 9.1 provides the details for all cities with more than 100,000 residents or more than ten murders in most recent years. The numbers involved here are generally subject to a greater proportion of noise than the numbers for the large cities nationally.

The contrast between New Jersey cities and the large cities outside New Jersey is stark. Except for East Orange, where numbers are small and noisy, all cities saw double-digit increases, and four saw increases larger than Newark.[7]

## 9.3   The Mechanics of Murder in Newark

The modal Newark murder today occurs late at night or early in the morning, with the body discovered on the streets. The weapon is a gun, and the victim is an African American man, usually with some sort of connection to drugs and gangs, but not one that can be readily ascertained or easily articulated. In this section, we show that these are the marginal murders, not just the modal ones, and we argue that they increased mainly because would-be murderers became more lethal in a variety of dimensions. This section is based on Newark Police Department (NPD) homicide and shooting logs and on autopsies by the state medical examiner.

7. New Jersey cities also depart from national trends in other respects. Over the period 1977 to 2006, the national rate dropped from a peak in 1980 to troughs in 2000 and 2004. Camden and Elizabeth had peak years in 1995, well after the national rate and the big cities began to fall, while for Irvington, East Orange, and Trenton, the record high years for murders occurred during the post-2000 upsurge.

**Table 9.2**       **Demographics of murder victims, 2000–2007 (under 12 years of age included in "other")**

|  | Black males | | | Black females | Hispanic males | Hispanic females | Other |
|---|---|---|---|---|---|---|---|
|  | 12–18 | 19–29 | 30+ |  |  |  |  |
| 2000 | 4 | 27 | 9 | 5 | 3 | 2 | 8 |
| 2001 | 5 | 33 | 10 | 10 | 12 | 2 | 23 |
| 2002 | 2 | 20 | 15 | 6 | 14 | 2 | 8 |
| 2003 | 5 | 32 | 22 | 12 | 9 | 0 | 3 |
| 2004 | 6 | 43 | 14 | 9 | 19 | 3 | 0 |
| 2005 | 10 | 44 | 25 | 6 | 9 | 0 | 4 |
| 2006 | 14 | 39 | 30 | 9 | 10 | 0 | 3 |
| 2007 | 13 | 40 | 19 | 8 | 6 | 2 | 11 |

### 9.3.1   Who?

Table 9.2 shows that murder victims in Newark are predominantly African American men, and almost all of the increase in murders has been among this group. (The large number of "other" victims in 2001 primarily reflects incomplete recording.) The overall increase in murder victimization over the period 2000 to 2006 was forty-three, or 107 percent for black males, and four, or 22 percent for everyone else. While murder has increased among all age groups of African American men, the largest increase has been among men over thirty. In contrast with the period studied by Blumstein, Rivara, and Rosenfeld (2000), this is consistent with stories about returning prisoners and inconsistent with stories about wild teenagers.

### 9.3.2   Why?

The NPD homicide log contains a short description of the motive for many murders (sometimes, of course, nothing is known for sure except that a body was found). Table 9.3 shows how these ascribed motives have evolved as murder has increased.

"Gang" means murders believed to directly further a gang's objectives and not otherwise classified as "drugs" or "disputes." "Disputes" includes murders where the parties are believed to be engaged in a conflict, but the police are unsure about what—it could be drugs, or women, or money owed, or whether the Nets have a stronger backcourt than the Knicks (even if the parties have gang or drug connections). "Disputes" also includes retaliations and murders where the police know what the dispute is about, but it is not drugs or gangs. "Domestic violence" includes traditional spousal murders as well as fatal incidences of child abuse, parent abuse, and fights between unmarried couples, gay or straight, who live together.

Disputes are the second most important motive, and rose considerably. This categorization probably understates their prominence, however,

**Table 9.3**                    **Newark murders by motive, 2000–2007**

|      | Gang | Dispute | Drugs | Domestic violence | Robbery | Unknown | Other | Total |
|------|------|---------|-------|-------------------|---------|---------|-------|-------|
| 2000 | 13   | 3       | 5     | 5                 | 2       | 27      | 3     | 58    |
| 2001 | 14   | 12      | 7     | 9                 | 8       | 41      | 4     | 95    |
| 2002 | 14   | 5       | 5     | 4                 | 5       | 30      | 4     | 67    |
| 2003 | 16   | 10      | 0     | 9                 | 4       | 39      | 5     | 83    |
| 2004 | 29   | 8       | 12    | 9                 | 5       | 19      | 12    | 94    |
| 2005 | 24   | 33      | 21    | 4                 | 11      | 1       | 4     | 98    |
| 2006 | 9    | 36      | 23    | 6                 | 11      | 11      | 9     | 105   |
| 2007 | 12   | 27      | 29    | 7                 | 8       | 15      | 1     | 99    |

because drug, gang, and domestic violence murders are also disputes. Taken together, these categories account for a substantial proportion of murders: 31 to 36 percent over the 2000 to 2003 period, 52 percent in 2004, 80 percent in 2005, 70 percent in 2006, and 76 percent in 2007. They also account for much of the growth in murder, rising by 129 percent if one compares the 2000 to 2001 average to the average in 2005 to 2006. What the large number of murders in the disputes category tell us is that the contentions that end with murder arise over a wide array of matters, not just drugs and gangs. "Disputes" also indicates that most murders happen in a context of *bilateral* animosity: both killer and victim have reason to wish ill for the other, even before the crime occurs.

Studying motives also indicates that murders in Newark do not occur primarily in some simple context like an organized war between two or three well-known gangs. To be sure, gang wars occur, and many victims and perpetrators are members of some sort of gang. But formal gang wars account for only a small proportion of murders. This heterogeneity in motives was also found in Colombia in the 1980s, despite the prominence of drug cartels and paramilitary organizations in accounts of this period. Gaviria summarizes the results of several studies: "Over 80% of all homicides in Colombia are the manifestation of an amorphous violence not directly related to a few major criminal organizations" (2000, 6).

### 9.3.3   How?

Both the marginal and the modal murder in Newark is accomplished by gunshot. The number of nongunshot homicides shows no trend between 2000 and 2006. Table 9.4 provides the details.

We can examine the reasons why gunshot homicides rose in more detail. Newark police keep detailed records on gun discharge incidents, and so we can investigate how gunshot murders rose. Newark investigators sort gun discharge incidents into three categories. "Shooting-hit" ($S_h$) is an incident in which a bullet wounds a person, but not fatally. "Shooting-no hit" ($S_{nh}$) is

**Table 9.4**    **Murders by gunshot wound in Newark, 2000–2007**

|  | Gunshot | Other | Total |
|---|---|---|---|
| 2000 | 41 | 17 | 58 |
| 2001 | 57 | 38 | 95 |
| 2002 | 49 | 18 | 67 |
| 2003 | 39 | 44 | 83 |
| 2004 | 74 | 20 | 94 |
| 2005 | 85 | 13 | 98 |
| 2006 | 91 | 14 | 105 |
| 2007 | 84 | 15 | 99 |

an incident in which a bullet is fired at a person, but does not hit him. "Shots fired" $(S_f)$ is an incident in which a gun is fired, and investigators do not know whether the shooter had an intended victim or sought only to send a message of ill will or warning. (Because shooting-no hit is distinguished from shots fired through an assessment of intention by an acknowledged victim or a police officer, many economists might prefer to ignore this distinction because in all these incidents, the shooter does something that increases somebody's probability of death. Accordingly, we perform all analyses in a way that allows readers to choose for themselves how to consider "shots fired.") The record is of *incidents,* not of gun discharges. A single incident may involve many shots. We define "gross gun discharge incidents" as the sum of gun discharge incidents and gunshot homicides $(H)$. Sometimes we will refer to gross gun discharge incidents simply as "shootings" $(S)$.

Our first attempt to understand why gun homicides rose is to decompose the transition from gross gun discharge incidents to gun homicides into several steps of increasing seriousness. By definition:

$$H = S - S_f - S_{nh} - S_h,$$

which yields the following identity:

$$\log H = \log S + \log\left(\frac{S - S_f}{S}\right) + \log\left(\frac{S - S_f - S_{nh}}{S - S_f}\right)$$
$$+ \log\left(\frac{S - S_f - S_{nh} - S_h}{S - S_f - S_{nh}}\right).$$

The second term on the right-hand side we call the *intention ratio* (the proportion of shots with intention to hit someone); the third term the *hit ratio* (the proportion of shots with intention that actually hit); and the third the *kill ratio* (the proportion of shots that hit that killed). Taking changes in these terms over time lets us see how much of the increase in gun homicides was due to more shootings, how much to a higher intention ratio, how much to a higher hit ratio, and how much to a higher kill ratio. Table 9.5 carries out this decomposition.

**Table 9.5**    **Decomposition of gun homicides in Newark (all magnitudes in natural logs)**

|  | Shootings | Intention | Hit | Kill | Gun homicides |
|---|---|---|---|---|---|
| 2000 | 6.402 | –0.451 | –0.250 | –1.987 | 3.714 |
| 2001 | 6.337 | –0.429 | –0.181 | –1.684 | 4.043 |
| 2002 | 6.277 | –0.469 | –0.156 | –1.761 | 3.892 |
| 2003 | 6.349 | –0.378 | –0.142 | –1.751 | 4.078 |
| 2004 | 6.486 | –0.411 | –0.127 | –1.644 | 4.304 |
| 2005 | 6.553 | –0.400 | –0.146 | –1.564 | 4.443 |
| 2006 | 6.537 | –0.357 | –0.130 | –1.539 | 4.511 |
| 2007 | 6.308 | –.302 | –.140 | –1.435 | 4.431 |
| 2007–2000 | –0.094 | 0.149 | 0.110 | 0.552 | 0.717 |
| Share (%) | –13 | 21 | 15 | 77 | 100 |

Gun homicides increased by more than 70 log points between 2000 and 2007, but shootings actually *decreased* over this period. The rise in homicides cannot, therefore, be attributed simply to more shootings. A higher proportion of shootings had intent to hit someone, and a higher proportion did hit someone, but the major story is that the probability of a murder conditional on a hit rose: 77 percent of the log rise in gun homicides is due to the higher conditional probability of death conditional on being hit by a gunshot. Murders rose mainly because shootings became more deadly, especially shootings where someone was wounded.

Why did shootings become more deadly? Possible answers are (a) potential murderers acquired better weapons with the capacity to fire more frequently, so a higher proportion of gross gun discharge incidents involved multiple shots, (b) potential murderers acquired higher caliber weapons that were more likely to kill when they did not make direct hits, (c) potential murderers acquired more skills, (d) potential murderers exerted more effort in trying to kill their victims (for instance, by standing closer to the victim or driving by more slowly or firing more shots), and (e) emergency medical care became less effective. These reasons have different implications for policy, as we shall see.

We can find out a lot about why shootings became more deadly by combining the information in the NPD shooting and homicide logs with autopsy reports from the state medical examiner. The appendix describes how we do this and the simplifying assumptions that we make. The results (reported in tables 9A.1–9A.3) allow us to attribute the rise in gun homicides above the 1999 to 2003 average to a series of different technical and behavioral changes. They indicate that gunshot homicides increased because of better marksmanship and greater effort, because of higher caliber weapons, because a larger proportion of gross gun discharge incidents involved multiple shots (either because of the presence of semiautomatic weapons or greater willingness of perpetrators to keep firing), and because the number of gross gun discharge

incidents increased. Our models are too crude for us to have much confidence in the exact attribution, but each of these factors seems to have made a significant difference. Shootings became more deadly in all dimensions.

Our conclusion that murders in Newark rose in the early twenty-first century because of greater intention to kill is similar to the conclusion that Swersey (1980) arrives at about a rise in murders in Harlem in the early 1970s (see Cook 1983). The phenomenon we are studying is not unique.

For policy and prediction purposes, an important distinction is between irreversible investments—greater skill and better hardware to the extent that resale is difficult—and transitory effort. Irreversible investments make lethality cheaper in the future and, thus, contain the seeds of hysteresis, but transitory effort does not. Our analysis suggests that both irreversible investment and effort contributed to the rise in gun homicide. Hysteresis is going to be a problem in reducing murders but not an insurmountable one. Our next task is to ask why potential murderers in Newark made these investments and undertook this effort. We need a formal model to do this.

## 9.4    A Model of Preemptive Murder and Endogenous Lethality

In this section, we provide an outline of a model and discuss its properties. For a more complete analysis with formal proofs, we refer the reader to our working paper (O'Flaherty and Sethi 2008).

The model has the following structure. Individuals are heterogeneous with respect to the costs they expect to incur when they commit murder, and these costs are private information. They may arm themselves prior to any dispute or choose to remain unarmed. Two types of weapon are available, with the more lethal weapon also being more costly to procure. Few individuals gain directly from the killing of others, but most would rather kill than be killed. Investments in greater lethality make one safer in the following sense: holding constant the investment made by one's opponent, the likelihood that one is killed is smaller when one's own lethality choice is greater. Investment decisions are characterized by strategic complementarity: greater investments in lethality by others heightens fear and induces individuals to increase their own investments. Multiple equilibria can arise quite naturally in this setting, and small changes in fundamentals can give rise to very sharp (and possibly discontinuous) changes in behavior. At such points of discontinuity, we show that the murder rate and investments in lethality both rise dramatically, while the overall incidence of shooting can decline. This is consistent with the Newark data.

### 9.4.1    Preliminaries

We have seen that most murders in Newark occur in circumstances where two parties bear some mutual animosity—disputes, gang fights, drug deals gone bad—and each may gain from the other's death. (Ex post, certainly,

the victim would have been better off had he killed his murderer first.) For ease of exposition, we assume that the parties to the conflict are ex ante identical (their characteristics drawn from the same probability distribution) although our results do not depend on this assumption of symmetry.

We use the term "interaction" to describe a dispute between two individuals that could potentially result in murder. This term should be interpreted broadly. It could be a fleeting exchange of fire lasting just a few seconds, or an extended feud, with the parties trying to ambush each other at opportune moments. Thus, a single interaction may spawn numerous unilateral gross gun discharge incidents over a period of many months. Indeed, victims almost never have guns in their possession when the police arrive. Sometimes the guns have been stolen after their death, but, in many cases, the victims had access to guns but were not carrying them when they were attacked.

Two types of weapon are available, one more lethal than the other. We define the lethality of a weapon to be the probability that its use in a single shooting incident will kill its target when the target is unarmed. Let $\alpha$ and $\beta$ denote the two available levels of lethality, with $\beta > \alpha > 0$. Individuals may endow themselves with either one of these weapons or remain unarmed. The cost of acquiring the more lethal weapon is $c > 0$, and the less lethal weapon is assumed for simplicity to be costless.

"Two types of weapon" should not be interpreted literally as an assumption about hardware. The assumption is that there are two ways to try to kill someone, and the more lethal one is more expensive in some way. Thus, the contrast could be between standard guns and semiautomatics that permit more shots in an incident; between small caliber guns and large caliber guns; between being untrained and being a skilled marksman; between firing while driving by at high speed and shooting point blank on the sidewalk; or between making little effort with haphazard fire and cool, concentrated, and close mayhem. The previous section suggested that murderers in Newark raised lethality by making all of these adjustments.

The probability that an individual is killed in any given interaction depends not only on the lethality of his opponent's weapon, but also on the lethality of his own. We assume that at most one individual is killed in any given interaction, and let $p(x, y)$ denote the probability that a player using lethality $x \in \{0, \alpha, \beta\}$ is killed when his opponent uses lethality $y \in \{0, \alpha, \beta\}$. Then $p(0, y) = y$, and $p(x, 0) = 0$ by definition. A plausible assumption is that $p(x, y)$ is decreasing in its first argument and increasing in its second: other things equal, a player is more likely to be killed if his opponent uses a more lethal weapon or if he himself uses a less lethal one. For instance, an individual who shoots first and misses may face return fire, and possession of a less lethal weapon makes this scenario more likely.

An example of an interaction structure that gives rise to a specific function $p(x, y)$ with these properties is the following. Suppose that each of the two players has at most one opportunity to shoot and that they fire in sequence.

Each player faces probability one-half of being the first to shoot. If the first shooter hits his target, the interaction ends. If not, the targeted individual shoots back, at which point the interaction ends regardless of the outcome. In this case,

$$(1) \qquad p(x, y) = \frac{1}{2}y + \frac{1}{2}(1 - x)y = \frac{1}{2}y(2 - x).$$

We shall assume throughout this section that $p(x, y)$ is given by equation (1); a more general treatment of the problem may be found in O'Flaherty and Sethi (2008).

   If neither player is killed, their payoffs are each normalized to 0. Otherwise, the victim's payoff is $-\delta$, and the shooter's payoff is $-\gamma$. This latter payoff reflects in part the likelihood of arrest and prosecution and the severity of the subsequent sentence. It also reflects the gains he realizes (other than his own survival) from the other party's death, as well as such factors as mood, anger, and the consumption of alcohol or drugs. Suppose that $\delta > 0$ and is commonly known, but $\gamma$ is private information, drawn (independently across players) from a probability distribution with full support on the real line. Hence, there are some individuals whose disutility $\gamma$ from successfully shooting someone is negative, even taking into account the risk of incarceration. The distribution function is denoted $F(\gamma)$, and the corresponding density function is $f(\gamma)$.

   If a player with cost $\gamma$ chooses lethality $x$ and is confronted by someone choosing lethality $y$, his payoff is

$$(2) \qquad \pi_{xy}(\gamma) = -p(x, y)\delta - p(y, x)\gamma.$$

This is the payoff from the interaction itself and does not include the cost $c$ that is incurred if $x = \beta$. Given $c$, $F(\gamma)$, and $p(x, y)$, equation (2) defines a Bayesian game in which each player chooses an action $x \in \{0, \alpha, \beta\}$ contingent on the value of his (privately observed) cost $\gamma$. Let $s(\gamma)$ denote an individual's strategy, which identifies with each value of $\gamma$ a level of lethality $x \in \{0, \alpha, \beta\}$.

   Suppose that a player believes that his opponent will use lethality $\alpha$ with probability $\lambda$, and lethality $\beta$ with probability $\mu$, where $\lambda + \mu \leq 1$. Then the expected payoff from choosing action $x$ is

$$\pi_x(\gamma) = -(1 - \lambda - \mu)\gamma x - \lambda[p(x, \alpha)\delta + p(\alpha, x)\gamma] \\ - \mu[p(x, \beta)\delta + p(\beta, x)\gamma].$$

A strategy $s^*(\gamma)$ corresponds to a symmetric Bayes-Nash equilibrium if the beliefs $(\lambda, \mu)$ of the players are correct conditional on the fact that they both adopt $s^*(\gamma)$, and $s^*(\gamma)$ is a best response to those beliefs (taking account of the cost $c$ if lethality $\beta$ is chosen).

   When $p(x, y)$ is given by equation (1), it can be shown that there exists at

least one symmetric equilibrium $s^*(\gamma)$. Furthermore, any such equilibrium has the following partitional structure: the lowest cost individuals choose lethality $\beta$, the highest cost individuals remain unarmed, and a set of individuals with intermediate costs choose lethality $\alpha$. Formally, there exist cost thresholds $\gamma_1$ and $\gamma_2$ such that $\gamma_1 < \gamma_2$ and $s^*(\gamma) = \beta$ for $\gamma < \gamma_1$, $s^*(\gamma) = \alpha$ for $\gamma \in (\gamma_1, \gamma_2)$, and $s^*(\gamma) = 0$ for $\gamma > \gamma_2$. In order to see how these thresholds vary with the values of the underlying parameters, let $\omega = \lambda\alpha + \mu\beta$ denote the likelihood of being killed conditional on being unarmed, and let $c' = c/(\beta - \alpha)$ denote the cost of switching from $\alpha$ to $\beta$ normalized by the resulting increase in lethality. Then the thresholds $\gamma_1$ and $\gamma_2$ can be expressed as simple functions of $\omega$ and $c'$ as follows:

$$(3) \qquad\qquad \gamma_1 = \frac{\delta\omega - 2c'}{2 - \omega} \text{ and } \gamma_2 = \frac{\delta\omega}{2 - \omega}.$$

In any interaction, the likelihood of a murder is $\omega(2 - \omega)$, the expected value of gun discharges is $(\lambda + \mu)(2 - \omega)$, and the ratio of murders to gun discharges is, therefore, $\omega/(\lambda + \mu)$.

We shall refer to $\omega$ as the level of *danger*. One can also think of $\omega$ as the level of "tension," to use the term often used by police to describe the situation that prevails before murders. When people are tense, they jump to respond to any provocation or danger, real or imagined. Tension begets murders, and murders, in turn, raise tension. In this sense, our model can be interpreted as an analysis of equilibrium tension.

Because $\omega$ is endogenously determined, equation (3) is consistent with the occurrence of multiple equilibria. However, because $\omega$ uniquely determines the thresholds $\gamma_1$ and $\gamma_2$, it also uniquely determines the probabilities $\lambda$ and $\mu$ with which the levels of lethality $\alpha$ and $\beta$ are used. Hence, there can be at most one equilibrium corresponding to any given value of equilibrium danger $\omega$. We next explore conditions under which multiple equilibria exist.

### 9.4.2  Multiplicity of Equilibriums

One of the key questions here is the manner in which changes in the distribution of costs $F(\gamma)$ affect the set of equilibria. To this end, we introduce a shift parameter $a$ and write the distribution of costs as $F(\gamma, a)$. We adopt the convention that for any pair $a, a'$ satisfying $a > a'$, we have $F(\gamma, a') > F(\gamma, a)$. That is, a decrease in $a$ shifts the distribution to the left, corresponding to an overall decline in the expected costs of attempted murder (or an increase in the expected gains, not including survival). Such a shift could be induced, for instance, by a decline in the effectiveness of the criminal justice system.

The following example illustrates the possibility that a small decline in $a$ can cause large and discontinuous changes in the level of lethality chosen and in the murder rate.

EXAMPLE 1. Suppose that $\alpha = 0.2$, $\beta = 0.6$, $\delta = 20$, $c = 1$, $p(x, y) = y(2 - x)/2$, and $\gamma$ is normally distributed with variance 1 and mean $a$. If $a = 1.03$, there exist three equilibria with levels of danger $\omega = 0.18$, $\omega = 0.23$, and $\omega = 0.60$, respectively. If $a = 1.02$, however, there is a unique equilibrium with $\omega = 0.60$.

This example illustrates that a small shift in the cost distribution can result in a large, discontinuous change in equilibrium danger. Figure 9.3 shows how the entire set of equilibria varies with $a$ over the range [0.9, 1.4] for the specification used in Example 1. (Note that the horizontal axis is reversed.) Suppose that one begins on the lower arm of the equilibrium set, and $a$ declines to the point at which equilibrium becomes unique. Such a decline results in an upward jump in the murder rate that can be very difficult to reverse. Even if the value of $a$ were restored to its original magnitude, the existence of multiple equilibriums when $a$ is large implies that the society may be trapped in a state with a high level of danger, lethality, and killing. Declines in the murder rate, if they are to be sustainable, require swift and substantial reductions in the level of fear.

It is useful to see what happens at the point of discontinuity to the level of danger $\omega$, the murder rate, gross gun discharge incidents, the proportion $\lambda$ using lethality $\alpha$, the proportion $\mu$ using lethality $\beta$, and the proportion $1 - \lambda - \mu$ who remain unarmed. These shifts are depicted in figure 9.4. As the threshold value of $a$ is crossed, the level of danger jumps up discontinuously as both the unarmed and the individuals using lethality $\alpha$ switch to the higher lethality $\beta$. The use of the less lethal weapon collapses to practically zero, as does the proportion of the population who choose to remain unarmed. The murder rate rises discontinuously, but total gun discharges *decline*. This is because the higher level of lethality results in lower victim survival and, hence, a reduced likelihood of a retaliatory strike. More generally, the effect of a rise in $a$ on shootings is theoretically ambiguous.

Notice that even before the point of discontinuity is reached, the level of danger and the rate of lethality begin to rise at an increasing rate. As the environment becomes more dangerous, more parties switch to higher lethality, which, in turn, makes the world more dangerous. Danger is increasing not only because there are more violent people, but also because people who were formerly nonviolent are switching to violence. The number of murders also grows more quickly, but the number of gross gun discharge incidents does not increase as rapidly as the number of murders. This is because greater lethality makes it more likely that feuds will end quickly. This is consistent with the Newark experience.

### 9.4.3   The Murder Multiplier

Many analyses of murder (and other crimes) do not take game-theoretic considerations into account. They work with a single-actor decision problem
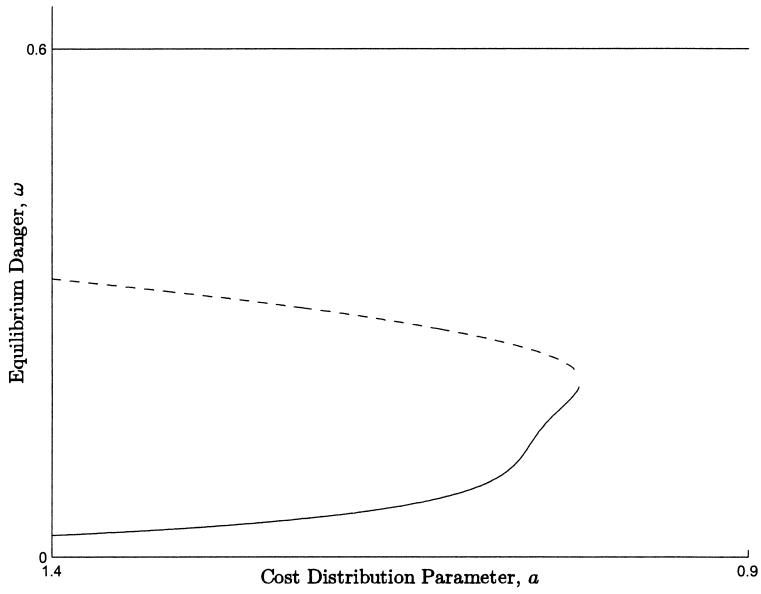
**Fig. 9.3    Effects of changes in *a* on the set of equilibria**
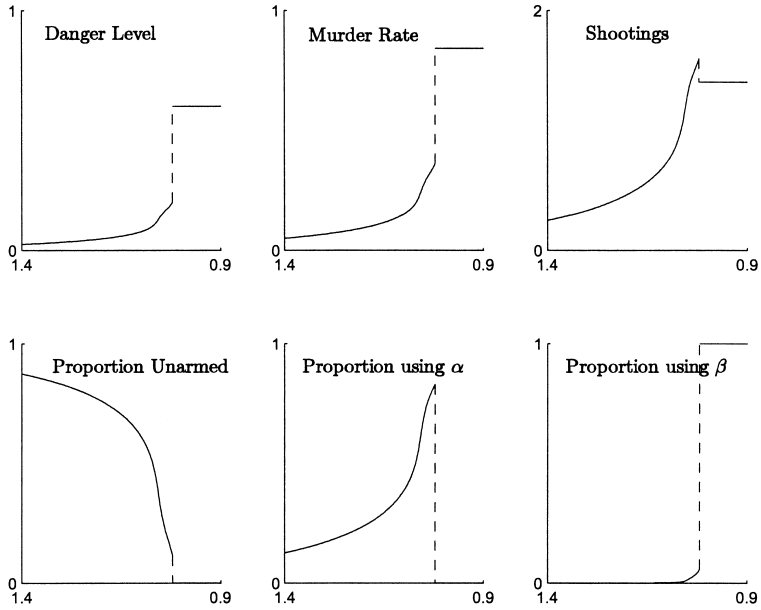


**Fig. 9.4    Equilibrium danger, murder, shootings, and lethality**

and ask what would make a person viewed in isolation more or less likely to commit murder. To link our approach to that literature, we ask what levels of shooting would prevail if no party had a preemption motive.

This is equivalent to asking what level of lethality would be chosen by an actor who was certain that his opponent was unarmed. Using equation (2), such an individual would choose lethality 0 if $\gamma > 0$, and lethality $\beta$ if $\gamma < -c'$. If $0 > \gamma > -c'$, then lethality $\alpha$ is chosen. Accordingly, we define autonomous shooting probabilities as follows: $\tilde{\lambda} = F(0) - F(-c')$, and $\tilde{\mu} = F(-c')$. The autonomous level of danger is then $\tilde{\omega} = \alpha\tilde{\lambda} + \beta\tilde{\mu}$.

The analogy is with autonomous expenditure in the simple Keynesian model of goods market equilibrium. In that model, equilibrium expenditure is greater than autonomous expenditure because of strategic complementarity: more autonomous spending by the government, say, induces consumers to spend more, which induces other consumers to spend more, and so on. The ratio of equilibrium to autonomous expenditure is the multiplier. In our model, there is a murder multiplier that also operates through strategic complementarity, and makes equilibrium murders greater than autonomous murders. More precisely, we can prove that the autonomous shooting probability $\tilde{\lambda} + \tilde{\mu}$ is always less than the shooting probability in *any* equilibrium, and if the cost of victimization $\delta$ is sufficiently high, then the autonomous level of danger $\tilde{\omega}$ is always less than any equilibrium level of danger. It follows that autonomous murder is less than equilibrium murder.

More formally, consider any equilibrium, and let $(\lambda^*, \mu^*)$ denote the equilibrium rates of use of $\alpha$ and $\beta$ weapons, respectively, and $\omega^*$ the corresponding level of danger. Then it can be shown that (a) $\lambda^* + \mu^* > \tilde{\lambda} + \tilde{\mu}$, and (b) if $\delta \geq c'$, then $\omega^* > \tilde{\omega}$. The condition $\delta \geq c'$ is unrestrictive, requiring only that the cost of murder victimization exceed the unit cost of greater lethality. Moreover, because the murder rate is increasing in the level of danger, equilibrium murders exceed autonomous murders when this condition is met.

Somewhat surprisingly, the preemptive motive can actually reduce murders relative to the decision-theoretic benchmark if $\delta$ is sufficiently small. The reason is that the game theoretic equilibrium takes into account the possibility that if one is shot before one can shoot, the lethality of one's weapon becomes irrelevant, and a costly investment in greater lethality is wasted. Possession of a more lethal weapon does make it less likely that one is shot, but when $\delta$ is small, this provides a negligible incentive to invest.

### 9.4.4    Comparative Statics

The preceding example shows that a decline in $a$ can cause the equilibrium set to change in a manner that results in discontinuous increases in lethality and danger. Similar effects can arise as a result of changes in other parameters of the model. Specifically, it can be shown that there exists a strictly increasing function $\varphi : [0, \beta] \rightarrow [0, \beta]$ such $\omega = \varphi(\omega)$ if and only if $\omega$ is an
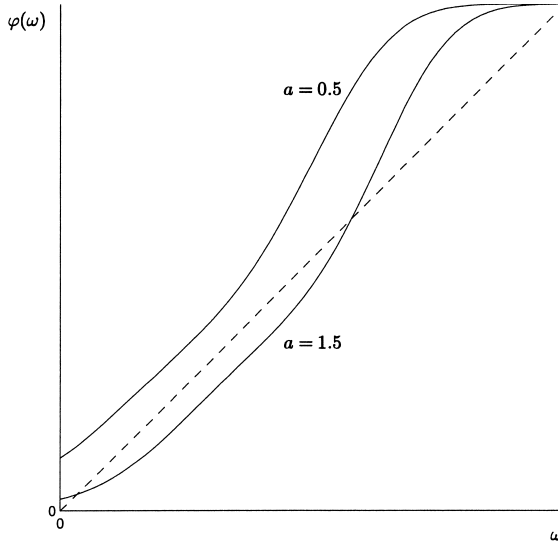
**Fig. 9.5    The function $\varphi(\omega)$ for two values of $a$**

equilibrium level of danger. The function $\varphi(\omega)$ is decreasing in $a$ and $c$ and increasing in $\beta$ and $\delta$.

The function $\varphi(\omega)$ may be viewed as a best response function: if individuals choose optimal strategies based on the belief that the level of danger is $\omega$, then the realized level of danger will be $\varphi(\omega)$. The fact that optimal strategies depend only on $\omega$ (and not on the underlying values of $\lambda$ and $\mu$) makes this case especially tractable. The function $\varphi(\omega)$ is given by

$$(4) \qquad \varphi(\omega) = \alpha F\left(\frac{\delta\omega}{2-\omega}\right) + (\beta - \alpha)\, F\left(\frac{\delta\omega - 2c'}{2-\omega}\right).$$

Note that by definition, the level of autonomous danger is $\widetilde{\omega} = \varphi(0)$.

As an example, suppose that $\gamma$ is normally distributed with mean $a$ and variance 1, and all parameter values are as in Example 1. Figure 9.5 shows $\varphi(\omega)$ for two different values of $a$. When $a = 1.5$, there are three equilibria. Declines in $a$ (which correspond to a shift to the left in the cost function) shift $\varphi(\omega)$ upward. At some value of $a$, the equilibrium set contracts in size, and there is a unique equilibrium with a high level of danger.

In general, any change in the primitives of the model that causes the function $\varphi(\omega)$ to shift upward can result in the kind of effect identified in figure 9.5, with discontinuous changes in equilibrium danger and the lethality and extent of weapon use. A discontinuous rise in equilibrium danger can be triggered by (a) a shift to the left in the net penalty distribution $F(\gamma)$, (b) a decline in the cost of high lethality $c$, (c) an increase in the disutility of

victimization δ, or (d) an increase in the highest level of feasible lethality β. These effects are all intuitive in sign, given the importance of the preemptive motive for murder. In each case, a small parameter shift can give rise to a cascade of expectations resulting in sharp increases in danger. While the initial (disequilibrium) effect of the change may be small, individual responses to the change induce even greater responses from others.

The effect on equilibrium danger of increases in α are ambiguous. On the one hand, murders increase because those choosing lethality α are more likely to strike their targets. On the other hand, the narrowing of the gap between β and α raises the effective price of lethality $c'$ and induces fewer individuals to adopt the more lethal weapon. Hence, somewhat paradoxically, a rise in the lethality of some weapons, holding constant the lethality of others, can result in reduced equilibrium danger.

To summarize, the sharp increase in murder rates could have been triggered by one or more of the following: the availability of weapons of greater lethality or lower cost, a greater aversion to being victimized (which encourages preemptive first strikes), or a general decline in the expected penalties faced by offenders. The key point is that a small change in any of these parameters can give rise to sharp, discontinuous changes in murder rates due to the cascading effect of expectations coupled with the preemptive motive for killing.

### 9.4.5    Peaceable Kingdoms and War Zones

In most of the United States most of the time, murder is a rare event. A non-Hispanic white woman was about 3.7 times as likely to die from an unintentional fall in 2002 as to be murdered (Minino et al. 2006, table 9). How can we account for this fact in our model? The basic reasons why murder is rare most of the time are that the autonomous level of murder is low and that at the autonomous level of murder, few people are on the margin. For most people most of the time, there is not much to be gained from murdering someone, compared with the psychic and legal penalties that are likely to follow. If $\tilde{\omega} = \varphi(0)$ is very small and the $\varphi(\omega)$ curve is very flat, then there will be a stable internal equilibrium very close to 0 (see figure 9.5).

Note that from equation (4), we have

$$\varphi'(\omega) = \frac{2}{(2-\omega)^2} \left[ \alpha\delta f(\gamma_1) + (\beta - \alpha)(\delta - c')f(\gamma_2) \right].$$

If $f(\gamma_1)$ and $f(\gamma_2)$ are both very small because almost no one is on the margin between becoming armed and remaining unarmed, then the $\varphi(\omega)$ curve will be very flat, and there will be a stable equilibrium very close to $\tilde{\omega}$. This depends both on the intercept $\tilde{\omega}$ and the slope $\varphi'(\omega)$ being small. The first depends on $F(0)$ and $F(-c')$ being small; the second on $f(0)$ and $f(-c')$ and the density function in their respective neighborhoods being small. Both conditions are probably often met for many modern American communi-

ties. We call such communities *peaceable kingdoms*. In such communities, comparative statics on $\widetilde{\omega}$ are a good approximation to comparative statics on $\omega^*$, and the standard single-actor analysis is not especially misleading. Thus, in most times and places, ignoring preemption is not a serious error.

When the level of danger is great, even at a stable internal equilibrium, the multiplier is large, and comparative statics are different from comparative statics on $\widetilde{\omega}$. Effects usually work in the same direction, but they are magnified. We call communities with a lot of danger and a large multiplier *war zones*.

We can show, in fact, that even at stable internal equilibria, as danger grows, the effects of parameter changes grow infinitely large, even before a discontinuous jump to a new equilibrium. To see this, we introduce a shift parameter $q$ and write the best response function as $\varphi(\omega, q)$. Assume that the derivative $\varphi_2(\omega, q)$ is positive and bounded away from 0 for all $\omega$ and $q$. Define

$$\hat{\omega}(q) = \inf \{\omega \mid \omega = \varphi(\omega, q)\}.$$

This is the lowest level of danger consistent with equilibrium for any given $q$. Suppose that for all $q$ in some closed set $[\bar{q}, \hat{q}]$, we have $\hat{\omega}(q) < \beta$, and $\hat{\omega}(q)$ has a discontinuity at $\hat{q}$. Then $\lim_{q \to \hat{q}^-} \hat{\omega}'(q) = \infty$. Hence, small changes in underlying parameters can give rise to very large effects on equilibrium danger (and, hence, equilibrium murder) in places that are very violent. War zones are like this, and peaceable kingdoms are not.

### 9.4.6    Dynamics

What happens when this game is played repeatedly? A fully developed intertemporal model is clearly beyond the scope of this chapter, but we can point in some general directions. If the cost required to produce lethality is an irreversible investment, then lethality produced in one period reduces the cost of lethality in subsequent periods. Lower cost of lethality in subsequent periods implies more murders in subsequent periods. So if irreversible investments are what produce lethality, murders today increase murders tomorrow, ceteris paribus. Examples of irreversible investments include skilled marksmanship and the transaction costs involved in acquiring guns.[8]

This prediction is based on a model of myopic decision making, but the basic conclusion should be robust. Consider a rational expectations world and a surprise change in fundamentals in period $t$ that increases equilibrium murder and lethality. The murder shock raises irreversible investments in period $t$, and so raises murder in period $t + 1$, no matter what period $t + 1$ fundamentals are. Seen from period $t - 1$, expected murders are higher in

---

8. The relevant cost of using a gun one already owns is the opportunity cost, the money one could make selling or renting it to someone else. But because illegal gun markets have huge transaction costs, this is usually well below the acquisition cost. See Cook et al. (2005).

period $t + 1$ than if the period $t$ shock had never occurred. That is, expected $t + 1$ murders conditional on a positive murder shock in period $t$ are greater than unconditional expected $t + 1$ murders. Comparing two communities with the same fundamentals and different histories, the community with more murders in the past will have more murders today.

Selection of agents may also affect intertemporal dynamics. Suppose that net murder costs $\gamma$ are positively correlated over time within individuals: people with low net costs today are likely to have low net costs tomorrow. Within any population, those with higher $\gamma$ are more likely to be murdered. Under weak conditions, the distribution of $\gamma$ tomorrow will be stochastically dominated by the distribution today. The population will grow more dangerous over time as less dangerous individuals are weeded out. On the other hand, incarceration could work in the opposite direction.

## 9.5   Prediction Biases

Criminologists and economists have produced an impressive empirical literature on homicide. This literature can help us understand what set off the rise in Newark murders and what policies are likely to reverse this trend. The general message of this literature is that fundamentals and incentives matter: police, arrest rates, and incarceration usually reduce murder. Not every paper finds that every incentive matters, but many find that these standard variables reduce murder. Murder is not unpredictable.

Our model of preemptive murder, however, indicates that some of the estimates of the size of these effects are likely to be too low for Newark in this decade. There are two general reasons. First, responses to policies are likely to be greater in situations where the level of danger is high than in situations where the level of danger is low. An equation fitted on a data set in which most communities have small murder rates will find much smaller average responses than prevail in communities where danger is high. Studies that report on average responsiveness are likely to underestimate the size of responses in places like Newark. We call this problem *nonlinearity prediction bias*.

Second, studies that define narrowly the type of murders that a particular policy is supposed to affect may underestimate the policy's effect for two reasons. They may miss murders outside the narrow circle that they draw that were really affected by the policy, and, worse, they may use these murders that should be inside the circle as a comparison group. For example, suppose we want to study a particular policy targeted at husbands who kill their wives. What happens if we look only at murders committed by husbands? Our preemption model tells us that there is a first-order bias in this research strategy because if husbands become less likely to kill wives, wives will be less likely to kill husbands. The proper procedure looks at both kinds of spousal murders. The problem is exacerbated if the study uses murders of husbands by wives as a control group. We call this problem *narrow-estimation bias*.

We begin with the arrest rate because it is the most traditional deterrence variable and possibly a major part of the Newark story. Levitt (1998) uses panel data for fifty-nine large cities for 1970 to 1992 to find the effect of arrest rates on various crimes. For most crimes, he finds significant effects. But for murder, although some of his equations have significant coefficients, his final preferred conclusion has murder arrests associated with a tiny, insignificant rise in murders.

More recent papers show larger effects. Corman and Mocan (2005) use monthly data for New York City for the period 1974 to 1999. They used lagged arrests to avoid endogeneity problems and find significant negative effects comparable to an elasticity of –0.4. In an earlier paper, Corman and Mocan (2000) use data for a slightly different period but still find approximately the same elasticity.

Finally, Dezhbaksh, Rubin, and Shepherd (2003) use panel data for 3,054 counties for the period 1977 to 1996. They estimate a system of equations by two-stage least squares (2SLS). The arrest rate is endogenous but enters into the murder equation. They find a large and significant negative effect. Because most counties most of the time are peaceable kingdoms, these estimates are likely to be affected by nonlinearity prediction bias.

The effects of prison population are also included in many studies. Many of these, especially those using state or state-level data found no effect on murder. Zimring and Hawkins (1995) looked at a California time series in the 1980s, and Marvell and Moody (1994) used a panel of states. Katz, Levitt, and Shustorovich (2003) also use state panel data for 1950 to 1990; they do not find a significant effect of prisoners per capita on murder, but they do find that states with more noisome prison conditions, as proxied by prisoner deaths, have fewer murders.

Levitt (1996) is the most famous study of the effect of prison population on crime. With state data, he uses court-ordered releases as an instrument and finds significant effects (fewer prisoners, more crime) for most index crimes, but not for murder. State authorities may have been clever enough to preclude the release of would-be murderers when they faced these orders. More plausibly, remember that in war zones, the threshold $\gamma$ at which murder is committed is higher than in peaceable kingdoms. (This always holds for the threshold for attempting murder with $\alpha$-lethality and usually holds for the threshold for attempting murder with $\beta$-lethality.) Many marginal prisoners may often be between these two thresholds—they are neither homicidal maniacs (who would stay in prison almost always) nor choirboys (who would not be in prison in the first place). Thus, reductions in prison population would raise murders in war zones but not in peaceable kingdoms. Because most communities are peaceable kingdoms, Levitt's study could have missed the effect in war zones.

On the other hand, researchers using national data have found effects of prison population on murder. Bowker (1981) and Cohen and Land (1987) found modest effects. Devine, Sheley, and Smith (1988) and Marvell and

Moody (1997) use national time series for very long periods and find elasticities greater than one in absolute value. The latter paper argues that ordinary least squares (OLS) is appropriate because murderers are a small part of prison population and shows that murder does not Granger-cause prison population.

Our model suggests a reason why national time series data find large effects for prison population and state-level panels do not. Suppose most states are peaceable kingdoms and a few are not, but a large proportion of murders take place in the few that are not. Prisoners have a minuscule effect in peaceable kingdoms but a large effect in war zones. Then national data, being aggregates, are dominated by the war-zone effects, while the state panels are dominated by the peaceable kingdom effects. (Marvell and Moody [1997] try to explain the difference by interstate migration.)

Corman and Mocan (2005) also look at prison population in their analysis of New York City. Their explanatory variable is total prisoners from New York City, and they find a significant though small coefficient of –.08. Raphael and Stoll (2004) also use state panel data, but they consider prisoner releases and prisoner commitments separately. For murder, they find that the effect of a prisoner release is very close to the effect of a prisoner commitment but opposite in sign. Thus, changes in murder should depend approximately on changes in prison population, however they occur. Their estimates imply that a reduction of 1,000 in prison population, lagged a year, raises murders by between eleven and twenty-eight.

A number of papers also have results about police strength. Levitt (2002) uses a panel of 122 cities from 1975 to 1995. In his most convincing version, he uses firefighters as an instrument for police officers. He finds a significant elasticity of –0.9, which is larger than the elasticity of any other crime except motor vehicle theft. Dezhbaksh, Rubin, and Shepherd (2003) use police expenditures in their 2SLS system and find an indirect effect on murder but do not report the magnitude. On the other hand, Corman and Mocan (2000, 2005) in both of their papers include police strength as an explanatory variable, but it does not have a significant effect on murder in either. Dezhbaksh and Shepherd (2006) also found no significant impact of police expenditures on murder. They used a panel of states for the period 1960 to 2000. Because most police do not work on homicides, these negative results may not be surprising. Levitt believes his instrumental variable picks up cities with a culture that promotes spending on public safety; such a culture may produce large investments in homicide squads and training, even holding the total size of the police force constant. So the instrument may have more information about how much effort is devoted to murder than day-to-day changes in total police strength.

Finally, we should note that Glaeser and Sacerdote (1996) is a paper directly related to ours in that it tries explain the huge intertemporal and interspatial variance of crime rates by appealing to social interactions. They conclude, however, that the amount of social interaction is "almost negli-

gible in murder and rape" although it is much greater for petty property crimes. Our fundamental difference with Glaeser and Sacerdote is how they measure social interactions. Their model has two types of people: those who can be influenced to commit crime by whether their neighbors commit crime and those who cannot. (Influence in their model is contagion or imitation, not self-protection as in our model.) Their measure of social interaction is the proportion of people in the entire population who can be influenced in the average jurisdiction. In a sense, their findings are a confirmation of our assertions about peaceable kingdoms. Perhaps it would be more relevant for murder to measure social interactions by the proportion of people who can be influenced relative to the proportion committing the crime, not the entire population.

## 9.6    What happened in Newark?

Our story is simple: murders rose in Newark because criminal justice became less effective in several dimensions more or less simultaneously, and this set off a cycle where more people began killing for their own safety. The rise in murders was larger than the empirical literature predicts, but nonlinearity prediction bias could be at work. Several other factors, such as falling conviction rates and state prison segregation policies may also have mattered.

In this section, we will first argue that the model of preemption and increasing lethality that we developed in section 9.4 is consistent with Newark's experience. Then we document the deterioration of criminal justice and discuss how much of an increase in murder this may have caused. Finally, we look at some other possible explanations.

### 9.6.1   Congruence with the Preemption Model

The obvious testable implication of the preemption model is that the ratio of murders to gross gun discharge incidents should rise as murders rise. Clearly, this has been the case in Newark. Recall that the model predicts greater lethality even if the rise in murders is caused by deteriorating deterrence or a toughening of the population distribution. The type of guns that potential murderers use can change even if the relative price and availability of high quality guns stays the same.

An easy extension of the model to a world where people have many different ways, places, and times to kill each other also generates some testable propositions. First, suppose that agents have many different ways in which they can increase lethality, instead of just one. Then an increase in murder and lethality driven by deterrence deterioration is likely to use all available means of lethality enhancement—partly because of heterogeneity among agents and partly because of diminishing marginal returns. Again, that is what we see happening in Newark.

Second, suppose that agents have many different times and places at which

to try to kill their victims. Then we would expect to see the increase in gross gun discharge incidents spread fairly uniformly over times and places—not only because of heterogeneity and diminishing marginal returns, but also because stalking a victim has elements of a zero-sum two-person game where randomization is often part of the optimal equilibrium strategy. Lethality should rise everywhere at more or less the same rate, too. This, too, is consistent with what we see in Newark.

On the other hand, preemption effects work only within a social or business network. If I have no connection with you, I don't gain from killing you, and I don't fear you will kill me. Disputes presume some engagement. Thus, the preemption model is consistent with the rise in murder and lethality being confined to a single demographic group, African American men.

Many other stories about the rise in homicide are not consistent with these facts. For instance, if homicide rose because a particular type of weapon became cheaper or more easily available or better, we would not see an increase in lethality in all dimensions, but we would see a rise across all demographic groups. Worse emergency medicine would also be seen as a rise in murder across all demographic groups.

### 9.6.2    Arrest Rates

The ratio of arrests for murder to murders declined precipitously in Essex County, falling from 0.811 in 1998 to 0.462 in 2005. Arrests per murder is a crude indicator for the clearance rate because several individuals are sometimes arrested for one murder, because one individual may be arrested for several murders, and because arrests may not occur during the same year in which a murder is recorded. But it is the most widely available measure. Nationally, the ratio is currently close to one.

Table 9.6 shows how the arrest-murder ratio declined in Essex County while it remained fairly stable in the rest of New Jersey, in the aggregate.

What does this fall in arrest rates tell us about changes in murder? From 2000 to 2006, the Essex arrest rate fell 31 percent. If we use Corman and Mocan's –0.4 elasticity, the implication is a 12 percent increase in murders. If we think of the deterrent effect of an arrest as acting with a one-year lag, then the relevant comparison is between 1999 and 2005: a 42 percent decrease in the arrest rate, which implies a 17 percent murder rise. Dezhbaksh, Rubin, and Shepherd (2003) use linear specifications, not logarithmic. Their results imply two to five more murders using the contemporaneous approach, three to seven more using the lagged approach. The tops of these ranges are close to the respective Corman-Mocan implications.

These falling arrest rates may have been exacerbated by falling conviction rates. The Essex prosecutor's office during this period developed a flagrant reputation for failing to win convictions in homicide cases (Kleinknecht and Schuppe 2006). If the conviction rates were falling after 2000, then it would probably have contributed to the rise in murder. But we do not know whether

**Table 9.6**             **Arrest/murder ratio: Essex County and rest of state, 1998–2006**

|      | Essex County | Rest of state |
|------|--------------|---------------|
| 1998 | 0.811 | 0.847 |
| 1999 | 0.738 | 0.933 |
| 2000 | 0.602 | 0.908 |
| 2001 | 0.592 | 0.866 |
| 2002 | 0.477 | 0.872 |
| 2003 | 0.652 | 0.879 |
| 2004 | 0.463 | 0.816 |
| 2005 | 0.426 | 0.801 |
| 2006 | 0.418 | 0.917 |

*Source:* New Jersey State Police.

it was rising or falling. Moreover, econometric studies of conviction rates (as opposed to arrest rates) are rare.

The decrease in arrest rates appears to be a simple case of declining productivity, not the congestion in law enforcement that Gaviria (2000) describes in Colombia and Sah (1991) explains theoretically. (Freeman, Grogger, and Sonstelie [1996] also use a variant of the Sah model to explain interjurisdictional differences in crime.) There were actually fewer murder arrests in Essex County in 2005 than there were in 1999.

Murder, moreover, is only one piece of law enforcement agencies' workload. A rise in murder alone should not overwhelm these agencies because they can redirect resources from other activities. Thus, congestion is a serious problem only if most major crimes rise together (as they did in Colombia). But in Newark, most other crime was falling during this period. Reported robbery and aggravated assault fell by 30 percent between 2000 and 2006, and major property crime fell by a smaller percentage. This fall in other crime does not appear to be the result of improved police performance or enhanced deterrence; resources were not being sucked away from murder to reduce these other crimes. The arrest-offense ratio for these other crimes fell in Essex County even though the number of crimes decreased. Table 9.7 provides the details. In summary, law enforcement agencies were not overwhelmed; the arrest-offense ratio for murder did not fall because of congestion.

### 9.6.3  Prisoners

After rising steadily from 4,515 in 1994 to a high of 6,241 in 1999, the number of state prisoners originally sentenced from Essex County fell sharply to 4,408 by 2006. The decline was 29.4 percent from January 1999 to January 2006 and 15.4 percent from January 2001 to January 2006. Table 9.8 provides details and comparisons with other counties.

As we saw in the last section, studies differ widely on the effect of pris-

Table 9.7    **Change in other serious crime and in arrest rates, 2000 and 2006**

|  | Newark (% change in no. of offences) | Essex County arrest rates | |
|---|---|---|---|
|  |  | 2000 | 2006 |
| Robbery | −31.2 | 0.214 | 0.207 |
| Aggravated assault | −30.0 | 0.577 | 0.439 |
| Burglary | −28.0 | 0.147 | 0.131 |
| Motor vehicle theft | −6.3 | 0.013 | 0.006 |

*Source:* New Jersey State Police.

Table 9.8    **New Jersey state prison population by county, 1994–2006, selected years (no. of prisoners sentenced from selected counties; population in early January)**

|  | Essex | Hudson | Union | Passaic | Mercer | Camden |
|---|---|---|---|---|---|---|
| 2001 | 5209 | 2695 | 2327 | 2218 | 1197 | 3874 |
| 2003 | 4830 | 2455 | 2211 | 2179 | 1275 | 3477 |
| 2004 | 4789 | 2518 | 2268 | 2264 | 1395 | 3457 |
| 2005 | 4607 | 2388 | 2176 | 2204 | 1390 | 3404 |
| 2006 | 4408 | 2269 | 2238 | 2294 | 1345 | 3580 |
| Change 2001–2006 (%) | −15.4 | −15.8 | −3.8 | +3.4 | +12.4 | −7.6 |

*Source:* New Jersey Department of Corrections, Web site and personal communication.

oners on murder. Some studies find no effect, and Corman-Mocan's –0.08 elasticity implies only a 1.2 percent rise in murders. But the results of Devine, Sheley, and Smith (1988) and Marvell and Moody (1997) imply roughly a 20 percent murder increase in Essex County from 2000 to 2005. The results of Raphael and Stoll (2004) are consistent with those of Marvell and Moody and, in fact, imply a slightly larger increase in murder.

### 9.6.4   Police

According to the Federal Bureau of Investigation (FBI) Uniform Crime Reports, the number of police officers in Newark fell by 8.0 percent from October 31, 2000 to October 31, 2006. (Counting police officers is not an exact science, but this is the data source that Levitt used.) Levitt's (2002) results imply that this fall in police strength should have raised murders in Newark by 7.2 percent. However, several extenuating factors imply that policing in Newark may have contributed more to the rise in murders than Levitt's average indicates. During this period, the physical facilities of the NPD fell into severe disrepair, normal hours of work decreased, and the command structure went through several upheavals.

### 9.6.5    Accounting for the Increase in Murder

Taking upper bounds of these three ranges implies a predicted 51 percent rise in murders from 2000 to 2006; that is, an increase from fifty-nine to eighty-nine. Actual murders in 2006 were 105. The difference of sixteen is not statistically significant.[9] We might be tempted to say that these three changes—fewer arrests, fewer prisoners, fewer police—account for the whole rise in murders. Such a conclusion would be strained, however. The bottom of the ranges predict only about sixty-seven murders in 2006, not eighty-nine. The Marvell and Moody paper on prison population is much weaker than the Levitt paper on the usual criteria. And the three changes are not necessarily independent so that using them to compound each other is questionable. Instead, we interpret the upper bound accounting exercise as a demonstration that in combination with these three factors the amount of nonlinearity prediction bias does not need to be unreasonably large to account for most of the rise in murder. These three factors and a modest amount of strategic complementarity do a pretty good job of explaining what happened in Newark.

### 9.6.6    Other New Jersey Cities

A great deal of the change in North Jersey murders can be explained by the three fundamentals of arrests, prisoners, and police. These worsened everywhere but Paterson, and murders rose substantially everywhere but Paterson. The numbers of murders in other cities is so small, however, that noise makes comparisons unreliable.

### 9.6.7    Witness Intimidation

Witness intimidation is a major problem in Newark that contributes to the low arrest and conviction rates. It also contributes to murder directly because some murders are committed to keep witnesses from testifying. However, there are no measures of witness intimidation, and so it is impossible to tell whether it was increasing or decreasing during the period we are studying.

Witness intimidation has important elements of strategic complementarity. If several witnesses see a crime, and threats are more likely to be carried out if the defendant is acquitted, then the fewer witnesses testify, the greater the cost for any remaining witness to testify. Multiple equilibria are possible, including equilibria with codes of silence. O'Flaherty and Sethi (2010) provide a detailed analysis of witness intimidation.

---

9. The methods developed by Fisz (1955) and Detre and White (1970) indicate that the analog of a $t$-statistic for the null hypothesis that Poisson variables of 89 and 105 are drawn from the same distribution is slightly less than 1.15. Murders in Newark, however, are a stuttering Poisson process because sometimes multiple murder incidents occur. Considering 89 and 105 as stuttering Poisson variables would reduce the $t$-statistic further.

### 9.6.8  Drugs

Many murderers and murder victims are or were engaged in the illicit drug business, either as buyers or sellers or both. The reasons for this association between drugs and murder are well known: legal means of dispute resolution are not available to this business; markets are imperfect, and so deaths of particular individuals can present large and persistent profit opportunities for other individuals; cooperation with law enforcement can be very harmful to an enterprise, and so assassination of those who cooperate can be very profitable; and the marginal penalty for murder is small for many people in this business (the prospect of a life sentence for murder is less intimidating for a person who stands a very good chance of soon being sentenced to twenty years as a drug dealer than it is for someone who has committed no other crimes). Selection may also play a role as naturally vicious people may have a comparative advantage in this industry.

But nothing indicates that changes in illicit drug markets played a major role in the rise in murder in Newark. Generally, two sorts of changes could increase murders. First, an outward shift of the demand curve could increase the quantity of drugs sold and so raise the number of people involved in the industry. Tables 9.9 and 9.10 show no rise in the consumption of illicit drugs, at least up until the middle of the period. (More recent information is unavailable.)

Second, an increase in the difference between retail and wholesale prices would reflect a larger sum of money being allocated to industry employment and to ex post profits. More money would be involved in distributing the same quantity of drugs, and that money could give rise to more murders. Becker, Murphy, and Grossman (2006) argue that greater enforcement efforts increase this difference and Miron (1999, 2001) shows that enforcement efforts Granger-cause murders in a long U.S. time series and in a cross-section of nations. Table 9.11 shows estimated prices for major illicit drugs in New Jersey between 2000 and 2006. In North Jersey, the wholesale-retail markup fell on average. This should have reduced murders. The wholesale-retail markup rose in South Jersey; this may be why murders rose in Camden more than the changes in arrests, prisoners, and police predicted.

The ethnic pattern of the rise in murders in Newark provides weak corroboration for the assertion that drugs did not play a major role in the increase in murders. National data indicate that non-Hispanic blacks, non-Hispanic whites and Hispanics consume illicit drugs at roughly comparable rates, and Hispanics and blacks are both incarcerated at high rates for drug crimes.[10] Thus, changes in the drug business should have increased murders

10. At year-end 2005, 23.7 percent of black prisoners and 22.9 percent of Hispanic prisoners under state jurisdiction were charged with drug crimes. But overall, the rate of per capita imprisonment among Hispanics was around two-fifths of the rate among blacks (Harrison and Beck 2007).

**Table 9.9**    **Prevalence estimates of drug use in New Jersey, 1999–2005 (% of population aged 12 and over)**

|  | 1999 | 1999–2000 | 2000–2001 | 2002–2003 | 2003–2004 | 2004–2005 |
|---|---|---|---|---|---|---|
| Past month illicit drug use | 7.2 | 6.1 | 5.8 | 7.0 | 6.9 | 7.2 |
| Past year cocaine use | 2.1 | 1.5 | 1.3 | 2.2 | 2.0 | 2.0 |

*Source:* Substance Abuse and Mental Health Services Administration (SAMHSA), National Household Survey of Drug Abuse.

**Table 9.10**    **Emergency room mentions of heroin and cocaine, Newark metropolitan area, 1998–2002**

|  | Heroin | Cocaine |
|---|---|---|
| Jan.–June 1998 | 2,575 | 1,481 |
| July–Dec. 1998 | 2,437 | 1,349 |
| Jan.–June 1999 | 2,301 | 1,180 |
| July–Dec. 1999 | 2,433 | 1,137 |
| Jan.–June 2000 | 2,285 | 1,080 |
| July–Dec. 2000 | 2,114 | 1,043 |
| Jan.–June 2001 | 1,849 | 1,031 |
| July–Dec. 2001 | 1,869 | 384 |
| Jan.–June 2002 | 1,938 | 1,023 |
| July–Dec. 2002 | 1,793 | 378 |

*Source:* Substance Abuse and Mental Health Services Administration (SAMHSA), Drug Abuse Warning Network.

of Hispanics and possibly of whites in Newark, not just blacks. As we have seen, that did not happen.

### 9.6.9    Guns

Although gun homicides accounted for most of the increase in Newark murders, changes in the price and availability of guns probably did not make a major contribution to the murder rise. More guns and more lethal guns came to Newark because people wanted them and were willing to pay more for them, not because they were cheaper or easier to obtain.

Two strands of argument support this conclusion. First, national trends are different from Newark trends. Although murders by gunshot have been rising in Newark since 2000, they have not been rising nationally. National firearm homicides peaked in 1993 and fell by 47 percent to 1999. Between 1999 and 2006, they rose modestly, by 20 percent, so that 2006 firearm homicides were 37 percent below the peak in 1993. Because the wholesale gun market is national, this trend casts some doubt on a simple story about lower gun prices being responsible for more gunshot murders in Newark.

Table 9.11    Drug prices in New Jersey, first quarter of calendar year, 2000–2006 ($)

| | North Jersey | | | | | | South Jersey | | | | | |
| | Heroin | | Cocaine | | Crack | | Heroin | | Cocaine | | Crack | |
| | Kilo | Bag | Kilo | Bag | Kilo | Bag | Kilo | Bag | Kilo | Bag | Kilo | Bag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 79 | 17 | 37 | 12 | 25 | 16 | 158 | 16 | 29 | 24 | 23 | 10 |
| 2001 | 71 | 10 | 26 | 10 | 23 | 14 | 177 | 15 | 27 | 22 | 25 | 16 |
| 2002 | 85 | 14 | 27 | 12 | 31 | 22 | 177 | 16 | 29 | 16 | 19 | 7 |
| 2003 | 63 | 11 | 25 | 14 | 24 | 22 | 98 | 16 | 27 | 24 | 19 | 10 |
| 2004 | 72 | 12 | 23 | 14 | 39 | 12 | 98 | 17 | 28 | 16 | 19 | 10 |
| 2005 | 67 | 9 | 25 | 14 | 26 | 14 | 98 | 22 | 25 | 22 | 19 | 14 |
| 2006 | 54 | 9 | 19 | 14 | 24 | 14 | 88 | 22 | 22 | 22 | 25 | 14 |
| % change | -32 | -47 | -49 | +17 | -4 | -12 | -44 | +37 | -224 | -8 | +9 | +40 |

*Source:* Drug Enforcement Administration (DEA), Illicit Drug Price Reports.
*Notes:* Point estimates calculated as geometric means of upper and lower limits of bounds given in original data. Kilo prices are in thousands of dollars.

**Table 9.12**                **Proportion of suicides by firearm in New Jersey, 1993–2003**

|       | % of total | % of African American | % of African American male |
|-------|------------|-----------------------|----------------------------|
| 1998  | 37         | 40                    | 43                         |
| 1999  | 35         | 48                    | 51                         |
| 2000  | 28         | 19                    | 22                         |
| 2001  | 28         | 41                    | 46                         |
| 2002  | 32         | 42                    | 44                         |
| 2003  | 31         | 28                    | 37                         |
| 2004  | 31         | 33                    | 40                         |

*Source:* New Jersey Department of Health and Senior Services.

Indeed, because the rise in gross gunshot discharge incidents is a relatively small part of the story of rising gunshot murders in Newark, the only way gun prices could have had a major impact would be for the price of high-quality guns to fall relative to the price of low-quality guns. But if that were to be happening on the wholesale level, other cities would experience the same rise in deadliness that Newark has experienced, and national gunshot murders would increase. Thus, the gun-diffusion explanations in Gaviria (2000) and Blumstein, Rivara, and Rosenfeld (2000) probably do not apply to Newark.

Second, suicide data do not indicate greater availability of either all guns or better guns in New Jersey. Some researchers have used the proportion of suicides that occur by gunshot as an indicator of the how available guns are in an area (see, for example, Cook and Ludwig 2006). The logic is the following: If guns are easy to acquire, then almost everybody attempting suicide will use a gun. If guns are hard to acquire, then almost nobody attempting suicide will use a gun. So if we observe that a high proportion of suicides are by gun, we can conclude that guns are easy to obtain and vice versa. Similarly, if we observe a rising proportion of suicides by gun, we can conclude that guns are easier to obtain.

Table 9.12 provides information on suicides in New Jersey. There is no evidence of an upward trend although the numbers involved are small. Because the data report on *successful* suicides, a rise in the *quality* of guns, holding everything else equal, would increase the proportion of gunshot suicides. This table is weak evidence against the hypothesis that easier gun availability is driving the rise in gun murders. If guns were easier to obtain, we would expect to see them used more often for suicides as well as for homicides.

On the other hand, in 1998, New Jersey became the first and for most of this period the only state to segregate gang members in a particular prison, East Jersey State. Cook et al. (2005) show that personal networks are crucial to the operation of illegal gun markets. Prison segregation may have improved networks among New Jersey gang members, making it easier for

them to obtain high quality guns. This would explain why New Jersey cities (except Paterson) are so different from almost all cities in the rest of the nation. But this argument is entirely speculative.

### 9.6.10   Unemployment

Between 2000 and 2006, unemployment rose in Newark and then fell back almost to its original level. According to the New Jersey Department of Labor and Workforce Development, the Newark unemployment rate rose modestly over the period, from 8.0 percent in 2000, to 8.5 percent in 2005, and to 8.3 percent in 2006, although it was much higher in some of the intervening years.

Raphael and Winter-Ebmer (2001) is probably the most rigorous study of unemployment effects on crime. They find significant positive effects for most crime: most crimes go up when unemployment goes up. But for murder they find negative effects, which are significant in several specifications with instrumental variables. Cook and Zarkin (1985) also find that murder is procyclical.

Hence, the business cycle did not contribute to the rise in murder in Newark and may even have reduced it.

## 9.7   Policies to Reduce Murder

No matter why murders rose, making them fall is a worthwhile goal. In this section, we will examine three programs for murder reduction for which claims of efficacy have been made, evaluate them in light of both the empirical literature and our model, and finally make some recommendations about how to reduce murders in Newark.

### 9.7.1   Programs That May Have Worked

Three murder-reduction programs in the last fifteen years have received considerable attention: Operation Ceasefire in Boston; Project Exile in Richmond, Virginia; and the combination of Compstat and broken windows in New York City. Murders fell substantially while all of these programs were in operation, but nobody knows what would have happened if the programs were not in operation. None of these programs has been subjected to a high quality test like a controlled experiment or a large natural experiment with an independent instrumental variable. Therefore, serious questions have been raised about whether each of these programs actually *caused* the reduction associated with it, and these objections are essentially unanswerable. There just is not enough independent variation. Rosenfeld, Fornango, and Baumer (2005) is a good summary of these programs.

Directed at youth, Operation Ceasefire in Boston involved direct communication with gang members that violence would not be tolerated. Police, youth workers, parole and probation officials, the U.S. attorney, and the local

district attorney all told gang members in a series of meetings, "We're here because of the shooting. We're not going to leave until it stops. And until it does, nobody is going to so much as jaywalk, nor make any money, nor have any fun" (Kennedy et al. 2001, 27–28). Posters described what happened to recalcitrant gang members: "They were warned. They didn't listen." The idea was to turn gang pressure into pressure against shooting. Simultaneous efforts were made to trace and interdict crime guns.

Richmond's Project Exile was directed at older offenders, not youth, but also employed an extensive communications strategy. Exile primarily involved sentence enhancements for violent or drug crimes involving guns. The method was federal prosecution because federal crimes carry longer sentences and higher bail, and federal prisons are out of state. These harsh sentences were announced with a media blitz: "An illegal gun will get you five years in federal prison," the billboards and ads said.

New York's strategy was two-pronged, and it is difficult to sort out their independent effects. One prong was strict accountability for police officers through Compstat, and the other was a crackdown on misdemeanors—the "broken windows" strategy named after Wilson and Kelling's (1982) famous article. There was no explicit public relations strategy, but the initiatives received enormous media coverage. The message was that police were getting tough, and the flood of misdemeanor arrests was in part meant to demonstrate to potential offenders that that was in fact the truth.

Thus, a public message was part of all three programs. That the message was public is crucial for our model. To change his behavior substantially, an agent needs to know not only that his payoffs have changed but also that the payoffs of the agents he interacts with have changed too. All three programs tried to accomplish both tasks.

All three programs also tried to punish both shootings and murders. This strategy was not explicitly part of our model, because all that mattered was the expected net cost of given lethality. But because shootings are much more common than murders, certainty may have more deterrent value than severity, and actual punishments are probably needed for credibility, the strategy seems reasonable.

We have already noted that all three programs have received both favorable and unfavorable evaluations, but our model suggests that the unfavorable evaluations of Ceasefire and Exile may be too harsh because of narrow-estimation bias. The consensus among peer-reviewed papers is that broken windows did not reduce murders, but the evidence is inconclusive on Compstat.

In Braga et al. (2001), Kennedy et al. (2001), and Piehl et al. (2003), the Ceasefire research team looked at the time series of youth gun homicides, youth gun assaults, and shots-fired calls in Boston. They found reductions in youth violence in the Boston time series, controlling for a number of trends, including adult homicides, and in comparison with twenty-nine other New

England cities and thirty-nine large U.S. cities. Because youth homicides may have influenced adult homicides, at least some of these tests were too strict, but Ceasefire passed them.

Rosenfeld, Fornango, and Baumer (2005), however, used a national data set of ninety-five large cities and controlled for a wide array of demographic and criminal justice variables, including police strength and incarceration, and found that the Boston decrease in youth gun homicide was not statistically significantly different from the sample average when the age group fifteen to twenty-four was used. With the age group eleven to twenty-four, the decrease was marginally significant. They note (434): "The lack of statistical significance reflects Boston's low youth firearm homicide counts during the intervention period (from 21 in 1996 to 10 in 1999)." Narrow-estimation bias may contribute to the problems of small numbers. Cook and Ludwig (2006) also raise questions about the power of the Ceasefire evaluations.

In contrast, Rosenfeld, Fornango, and Baumer (2005) find a statistically significant decrease in gun homicides when they apply their methods to Project Exile, even though their point estimate of Ceasefire's effect was larger. Richmond had more homicides to work with. Raphael and Ludwig (2003), however, reached the opposite conclusion about Exile.

There are several differences between the two papers, most especially a controversy about how to treat the unusually large number of gun homicides in 1997, the year the intervention began but before much happened. More notable for us is that Raphael and Ludwig (2003) control for juvenile homicides in Richmond when they look at adult homicides in Richmond. We don't know what the effect of using this control is, but it is another example of possible narrow-estimation bias.

Raphael and Ludwig (2003) also argue that the reduction in murders in Richmond was mostly mean-reversion. Our model lets us interpret this argument and the data they present for it quite differently. They show that across cities the change in the natural log of gun homicide rates in the late 1990s, when rates were falling, was negatively correlated with the change between the mid-1990s and the mid-1980s. Cities that had bigger increases in the early decade had bigger decreases in the later quinquennium. Because Richmond had a large increase, mean reversion implies that it should have a big decrease, too. However, general evidence for mean-reversion in homicide rates is scant. Corman and Mocan check for it in New York City monthly data in both of their papers and cannot reject unit roots. The national murder rate time series over the past thirty years is clearly not mean-reverting.

Our model suggests an alternative interpretation for the correlation Raphael and Ludwig (2003) find. Suppose fundamentals change roughly the same way everywhere. Then war zones will have bigger increases in murder than peaceable kingdoms when fundamentals are getting worse and bigger decreases when fundamentals are getting better. If we compare a

period when fundamentals are getting better everywhere with a period when fundamentals are getting worse everywhere, the Raphael-Ludwig correlation will hold, even if murder rates are not a mean-reverting process. Thus, the Raphael-Ludwig correlation provides some weak confirmation for our model of murder.

This way of looking at murder rates also suggests another way of interpreting the conclusion from Rosenfeld, Fornango, and Baumer (2005) that Project Exile reduced murder rates significantly while Operation Ceasefire and the New York combination did not. Richmond had a much higher murder rate than either New York or Boston at the start of the interventions. Thus, the same intervention would have produced a bigger effect in Richmond than in the other two cities. Rosenfeld, Fornango, and Baumer (2005) may have found not that Project Exile was more effective but that Richmond was more receptive.

For New York, some papers test broken windows alone and some test the combination of broken windows and Compstat; no work tests Compstat alone. In their study using monthly data from New York City police precincts, Corman and Mocan (2005) include citywide misdemeanor arrests as an explanatory variable. Misdemeanor arrests have no significant effect on murder although they did reduce robbery and motor vehicle theft. Kelling and Sousa (2001) also studied New York City, but only for approximately a decade. They found that violent crime declined more in precincts that had more misdemeanor arrests over the decade, but they did not publish any results about homicide. They also do not control for own arrests or police strength and do not address reverse causation (less violent crime would allow police more time to make misdemeanor arrests). Harcourt and Ludwig (2006) show that neither of these studies could support a finding that misdemeanor arrests reduce crime (they use the Kelling-Sousa and Corman-Mocan approaches on misdemeanor arrests to demonstrate that success of the New York Yankees drives crime in New York)—although, in fact, neither study found that such arrests reduce murder.

The multicity study of Rosenfeld, Fornango, and Baumer (2005) tested broken windows and Compstat jointly by comparing New York's homicide rate decline with the national average, both adjusted for controls. They found that, adjusted for controls, New York's homicide decline was not bigger than the national average (the point estimate was that it was smaller, but insignificantly so).

Thus, while there are some indications that programs that involve public communications and concentrate on shooters as well as killers may have some efficacy, the evidence is not compelling for any particular program. (This is essentially the same conclusion that Levitt [2004] reaches in his review of the 1990s crime decline and that Cook and Ludwig [2006] reach in their review of gun violence.) Of course, the evidence for such traditional variables as arrest rates and police strength is fairly strong.

### 9.7.2    Implications for Newark

What do these results imply about policies for Newark to pursue? Consider first the effects of making more arrests for murder and convicting more guilty suspects. More resources devoted to these tasks probably have two multiplier effects: more arrests and more convictions make more witnesses come forward, and more witnesses lead to even more arrests and more convictions; more arrests and more convictions lead to fewer people willing to murder for gain; fewer people willing to murder for gain lead to fewer people killing for self-protection.

Expansions of the police department to accomplish this end probably pass cost-benefit tests. Levitt's (2002) elasticity of murder with respect to police strength implies that added police expenditures in general reduce murders at a cost of about $2 million per life in Newark, well below the value of most American statistical lives, though not above the value that Levitt and Venkatesh (2000) conclude that young gang members place on their lives. Expansions concentrated on homicide reduction should do much better, as we have argued in the literature review.

Second, public messages that heighten fear may be counterproductive. Billboards that say, "Stop the killing" tell rational people that a lot of killing is going on and they need to protect themselves; so do repeated assertions that murders are going up everywhere (which is not true). Repeated laments that witnesses never testify tell rational would-be witnesses that testifying is very dangerous.

Of course, public messages cannot be wrong or misleading either; one cannot tell people that drinking Newark water makes bullets bounce off them. Messages suggesting that more apprehensions are being made, or more witnesses are coming forward, or more old cases are being solved could be highly effective provided that they are credible. (It might also be worthwhile to publicize how abysmally inaccurate most Newark shooters are.) For this to work, of course, actual progress would have to be made on the necessary detective work and witness protection.

Raising the cost of holding high quality guns reduces murders with all types of guns and so can have a substantial payoff. How to do this is less obvious. Cook and Ludwig (2006) provide a useful summary of the empirical literature on gun control strategies. They find that directed patrolling against illicit carrying stands the best chance of reducing homicide.

Raising the marginal penalty for murder by reducing penalties for other crimes is a riskier strategy. Shifting police and prosecutorial resources from other crimes accomplishes this implicitly because the marginal penalty for murder depends on the expected punishment for having committed other crimes. If resources are shifted from those crimes that people contemplating murder are likely to have committed, or are likely to commit soon, then the marginal penalty for murder will rise.

Prisoner reentry programs also implicitly reduce penalties for nonmurder crimes and so raise the marginal penalty for murder. If your life is ruined for any crime you commit, then if you have committed any other crime, the marginal penalty for murder is small. (A rigorous statement of this proposition is in O'Flaherty 1998.) Making postprison life better for other crimes makes murder more costly. But this is a long-run effect that may not be of any relevance in the next few years.

Programs that focus on former prisoners have a second possible payoff. For reducing murder, the most crucial place to lower the probability density function of $\gamma$ is probably slightly above 0—people who would not kill if self-protection were not an issue but who do so readily when self-protection is an issue. In a different atmosphere or with a different crowd, they would not kill, but their willingness to kill in the dangerous environment they find themselves in encourages still more people to arm themselves and kill preemptively. If the probability density in neighborhood were to be decreased and moved to slightly higher values of $\gamma$, equilibrium murder would fall considerably. Former prisoners are probably heavily concentrated in this crucial range of $\gamma$.

How to change $\gamma$ for this group is not certain, however. Employment is likely to help because it will occupy their time and further many of their aspirations. But, in general and in the aggregate, there is scant evidence that employment reduces murder as Raphael and Winter-Ebmer (2001) and Cook and Zarkin (1985) have shown.

Recreation, broadly conceived, may be more strategic, considering the large number of disputes among Newark's murder motives. The key is finding things that thirty-year-old former prisoners like to do after work and helping them to do these things in an atmosphere without guns and where disputes are settled amicably or with fists. Churches may assist with this, but some effective forms of recreation may not be wholesome enough for churches or even the city to sponsor directly.

Recreational segregation may also reduce murder. Consider a society where the equilibrium number of murders is far above the number of autonomous murders (our picture of Newark today). To make the situation simple, assume $\beta = \alpha$, and so $F(0)$ is the number of autonomous murder attempts. Now split the society in two, with all agents with negative $\gamma$ in one new society and all those with positive $\gamma$ in the other new society. Aggregate murder goes down to the autonomous level: the positive-$\gamma$ society is murder-free, while in the negative-$\gamma$ society, everyone shoots everyone else—but all of these people were shooting in the original society anyway—and they would be the only people shooting in the original society at the autonomous murder rate. (In the long run, segregation may be even more effective because the negative-$\gamma$ society will steadily lose population from murder and incarceration, but the population of the positive-$\gamma$ society will stay the same.)

One way to increase recreational segregation might be to establish different

categories of bars and allow some categories greater privileges like later closing hours in return for restrictions like a no-guns policy. Privileges would be lost if a bar were connected to too many shootings. On the other hand, closing down the bloodiest bars promotes the kind of recreational integration that could increase the incidence of homicide. Murderers are going to go someplace, and it is better that they be with each other than that they be forced to associate with people who will as a result become killers in self-protection.

## 9.8   Conclusion

We have no direct empirical evidence about our primary theoretical contribution—the difference between autonomous and equilibrium murder that arises because of self-protective preemption—although results like those of Raphael and Ludwig (2003) can be interpreted as supportive. Clearly much good empirical work can and should be done in this area. A lot of theoretical work is missing, too—detailed models of segregation and models of witness intimidation have already been cited. In the meanwhile, we have good circumstantial evidence that strategic complementarity is a big part of the explanation for why murder rose in Newark and in other cities in North Jersey.

Substantively, murders can be reduced in Newark. Murders rose because small changes in fundamentals were magnified by a cycle of self-protective preemption (and probably also by a cycle of self-protective witness temerity). Some irreversible investments were made, but the changes in fundamentals needed to reverse the process, while larger than those that started the process, are probably not prohibitively large.

## Appendix

### *How Gunshots Became More Lethal*

In this appendix, we look at the ways in which gunshot wounds in Newark became more lethal in the early years of this century. In particular, we will try to infer how much of the change is due to changes in hardware (higher caliber weapons, semiautomatics, etc.) and how much of it is due to greater effort on the part of shooters.

We will combine information from the NPD homicide log, the NPD shooting log, and the record of autopsies maintained by the state regional medical examiner. We obtained the information from the medical examiner because the NPD did not collect reliable information on whether murders involved multiple wounds. Only an autopsy can determine whether multiple wounds

are involved (as opposed to "through-and-throughs"—bullets that create wounds on both entering and exiting the decedent's body). An officer on the scene of a crime does not have enough information on this question.

The medical examiner's office, however, does not classify homicides in the same way that the NPD does. For the medical examiner, a homicide is classified in Newark if the death occurs at a Newark hospital. For the NPD, a homicide is classified in Newark if the incident that causes the death occurs in Newark. Newark is a net importer of homicide victims, especially in recent years, as a number of close suburban hospitals have closed. With the cooperation of the medical examiner's office and the NPD, we were able to reconcile the two sets of records and report information on gun homicides where the shooting occurred in Newark.

We classified a homicide as "multiple wounds" if the medical examiner in describing the cause of death used either the phrase "multiple wounds" or the word "wounds." Staff from the medical examiner's office have told us that the phrases are used interchangeably with no particular significance attaching to one as opposed to the other.

Ideally, we would like to know how many shooting incidents involved multiple shots and how many shots they involved because then we could separate the effect of more shots from the effect of increased deadliness of the average single shot. But we do not have such information. The closest we come to it is the number of homicides with multiple wounds, and from that information, we have to infer the number of shooting incidents involving multiple shots. Within the category of multiple wound homicides, moreover, we do not know the number of bullets that hit the victim; we know only that it is greater than one.

Notice that an increase in the number of multiple shot shooting incidents raises the number of murders in two ways, holding the lethality of each shot constant. Obviously it increases the number of multiple-wound murders. Less obviously, it also increases the number of single-wound murders because a shooter who fires twice or three times is more likely to hit his target once than a shooter who fires only once. Thus, drawing inferences about the causes of rising lethality from the data we have will require a highly parametrized model with many assumptions. This has to be a highly stylized exercise.

We make the following assumptions: (a) in any shooting incident, either one shot or two shots are fired; there are never more than two shots fired; (b) throughout a year, all gross gun discharge incidents are homogeneous, except for the number of shots fired; (c) when two shots are fired, the probabilities of hitting are independent, as are the probabilities of being accurate enough to kill if only a single shot hit; (d) if a victim is hit twice, he will die. The fourth assumption biases our results to a finding that multiple shootings lead to many murders and makes the role of multiple shootings more important than if, for instance, we had assumed that only the most accurate

shot mattered. This assumption finds some support in Zimring (1972), who found that with the type of guns that are most in use now, almost all multiple wound shootings were fatal. But, of course, medical technology has improved along with gun technology since the 1970s.

These assumptions let us describe the shooting process with three nonlinear equations in three unknown probabilities. These are $d$, the probability that an assailant fires two shots; $h$, the probability that a shot hits a victim in such a manner that, if it were the only shot to hit him, it would not be fatal; and $m$, the probability that a shot hits a victim in such a manner that, if it were the only shot to hit him, it would be fatal. Let $\mu_2$ denote the empirical ratio of multiple wound murders to shootings in a particular year. (We calculate shootings with and without shots fired.) In order for a shooting to be a multiple wound murder, the murderer must shoot twice, and both of those shots must hit the victim. Hence,

$$(A1) \qquad\qquad \mu_2 = d(m + h)^2.$$

Let $\mu_1$ denote the empirical ratio of single wound murders to gross gun discharge incidents (with or without shots fired). A single wound murder could occur two different ways. The murderer could shoot once and kill; or he could shoot twice and kill with one shot and miss with the other. Hence,

$$(A2) \qquad\qquad \mu_1 = (1 - d)m + 2dm(1 - m - h).$$

Finally, let $\eta$ denote the empirical ratio of shooting hits to gross gun discharge incidents. A shooting hit could occur two different ways. The assailant could shoot once and hit but not kill; or he could shoot twice, with one shot hitting nonfatally and the other missing. Hence,

$$(A3) \qquad\qquad \eta = (1 - d)h + 2dh(1 - m - h).$$

We can solve equations (A1) to (A3) in each year to find the underlying parameters $d$, $m$, and $h$. Table 9A.1 shows the results of this exercise. Both versions (with and without shots fired) tell the same qualitative story. All three parameters generally rise over the period although not monotonically. (The NPD shooting log was just beginning to be kept in 1999, and the unusual results here may be the result of initial reporting difficulties.) The largest percentage increase is in $m$, the lethality of an individual shot. The probability $h$ that an individual shot wounds nonfatally increases the least in percentage terms, while the multiple-shot proportion $d$ rises by an intermediate percentage.

Two kinds of changes could be driving the rises in $d$ and in $m$: hardware and software. For $m$, the hardware change would be higher caliber weapons, and the software change could be better marksmanship and greater effort (approaching closer to the victim, for instance). For $d$, the hardware change would be weapons like semiautomatics that make it easier to fire more shots and to fire them more quickly, and the software change would be willingness

Table 9A.1            **Estimated parameters of the multiple shooting model**

| | Including shots fired | | | Excluding shots fired | | |
|---|---|---|---|---|---|---|
| | *m* | *h* | *d* | *m* | *h* | *d* |
| 1999 | 0.046 | 0.480 | 0.195 | 0.065 | 0.487 | 0.243 |
| 2000 | 0.024 | 0.421 | 0.191 | 0.041 | 0.715 | 0.105 |
| 2001 | 0.053 | 0.442 | 0.188 | 0.087 | 0.730 | 0.106 |
| 2002 | 0.051 | 0.441 | 0.178 | 0.087 | 0.757 | 0.097 |
| 2003 | 0.056 | 0.506 | 0.101 | 0.085 | 0.771 | 0.064 |
| 2004 | 0.052 | 0.477 | 0.217 | 0.086 | 0.780 | 0.123 |
| 2005 | 0.062 | 0.461 | 0.234 | 0.100 | 0.748 | 0.132 |
| 2006 | 0.061 | 0.496 | 0.229 | 0.094 | 0.767 | 0.137 |
| 2007 | 0.060 | 0.506 | 0.296 | 0.090 | 0.751 | 0.181 |

to take the time to fire more shots. Our data do not allow inferences about the relative importance of these changes in *d*, but an auxiliary model can allow us to infer something about the effect of higher caliber weapons in raising *m*, the single-shot fatality rate.

Assume that all shooters are aiming at the same target, and consider a single shot. If the shooter misses the target by less than *w*, a physical constant, the victim is wounded (we are assuming no growth in the body mass of victims during this period). If the shooter misses by less than $k < w$, the victim dies. Our key assumption is that *k* depends on the caliber of the weapon (higher caliber weapons imply a larger kill radius *k*), and *w* does not depend on the caliber of the weapon. A high caliber bullet that misses entirely has the same effect as a low caliber weapon that misses entirely. Finally, we assume that where shots actually hit relative to the target is distributed normally with zero mean and variance that depends on the skill and effort of the shooter. Let σ denote the standard deviation of shots in any year, and let Φ denote the standard normal cumulative distribution function. Then we have

(A4)
$$\Phi\left(\frac{k}{\sigma}\right) - \Phi\left(\frac{k}{\sigma}\right) = m,$$

(A5)
$$\Phi\left(\frac{w}{\sigma}\right) - \Phi\left(\frac{k}{\sigma}\right) = \frac{h}{2}.$$

We call $k/\sigma$ and $w/\sigma$ the normalized kill and hit radii, respectively. Equation (A4) says that single-shot murders occur when a shot hits within *k* of the target, and equation (A5) says that nonfatal wounds occur when a shot hits a distance from the target between *w* and *k*. Solving equations (A4) and (A5) yields

$$\frac{k}{\sigma} = \Phi^{-1}\left(\frac{1+m}{2}\right)$$

$$\frac{w}{\sigma} = \Phi^{-1}\left(\frac{1+m+h}{2}\right).$$

These values are shown in table 9A.2.

Two conclusions are immediate from this table. First, because the normalized hit radius is growing, either skill or effort or both is growing. Because $w$ is a physical constant, $w/\sigma$ can rise only if $\sigma$ falls, and a fall in $\sigma$ is better marksmanship or greater effort. Second, because the normalized kill radius is growing faster than the normalized hit radius, caliber must be increasing, too. If software were the whole story, then $k$ would be constant and $k/\sigma$ would fall at the same rate as $w/\sigma$). Thus, $k$ is rising, which is due to higher caliber.

Because all the relationships are nonlinear, to understand the relative importance of the changes in the different parameters, we perform a series of counterfactual calculations. In each of these calculations, we keep one parameter constant at its average value for 1999 to 2003 and find out how many murders would have occurred in a later year if all other parameters assumed their actual values. Thus, for instance, to find the effect of more multiple shooting incidents on 2006 murders, we ask how many murders would have occurred in 2006 if $d$ were reduced to its average value for 1999 to 2003 and all other 2006 parameters maintained their actual values. If reducing $d$ to its 1999 to 2003 average value reduces the number of murders in 2006 greatly, then we can say that the rise in $d$ contributed greatly to the rise in murders in 2006. We make these calculations for 2004, 2005, and 2006.

Specifically, we are interested in five sets of counterfactual scenarios:

**Table 9A.2**    **Estimated parameters of the target missing model**

|  | Including shots fired | | Excluding shots fired | |
|---|---|---|---|---|
|  | $k/\sigma$ | $w/\sigma$ | $k/\sigma$ | $w/\sigma$ |
| 1999 | 0.058 | 0.717 | 0.081 | 0.759 |
| 2000 | 0.031 | 0.591 | 0.052 | 1.167 |
| 2001 | 0.066 | 0.667 | 0.109 | 1.332 |
| 2002 | 0.064 | 0.661 | 0.109 | 1.420 |
| 2003 | 0.070 | 0.776 | 0.107 | 1.461 |
| 2004 | 0.066 | 0.722 | 0.108 | 1.498 |
| 2005 | 0.077 | 0.711 | 0.126 | 1.432 |
| 2006 | 0.077 | 0.767 | 0.119 | 1.481 |
| 2007 | 0.076 | 0.783 | 0.113 | 1.408 |

1. Shootings: How many murders can be attributed to the increase in the number of gross gun discharge incidents? We keep the number of shootings at its 1999 to 2003 average and let the ratio of gun homicides to shootings maintain its actual value in each later year.

2. Multiple-shots: How many murders can be attributed to the increase in the proportion of gross gun discharge incidents that involve multiple shots? We keep $d$ at its 1999 to 2003 value and let all other parameters maintain their actual values in later years. We use equations (A1) to (A3) to find $\mu_1$ and $\mu_2$ and multiply these imputed values by the actual number of gross gun discharge incidents.

3. Single-shot lethality: How many murders can be attributed to the increase in the lethality of a single shot? We keep $m$ at its 1999 to 2003 average value and let all other parameters maintain their actual values in later years.

4. Caliber: How many murders can be attributed to the increase in caliber? Essentially, we hold $k$ constant at its average value of 1999 to 2003 but let $\sigma$ and all other parameters evolve as they actually did. We call this the constant caliber scenario. Specifically, we calculate the ratio between average $k/\sigma$ and average $w/\sigma$ for 1999 to 2003 and then calculate what $k/\sigma$ would be in each of the years from 2004 through 2006 if $w/\sigma$ took its actual value, but the ratio between $k/\sigma$ and $w/\sigma$ stayed at its average 1999 to 2003 value. From these values of $k/\sigma$ and $w/\sigma$, we calculate $m$ and $h$ for these years and then calculate how many gun homicides would have occurred with these values of $m$ and $h$.

5. Marksmanship and effort: How many murders can be attributed to the increase in single-shot marksmanship and effort? This is the difference between the number of murders attributed to single-shot lethality and the number attributed to caliber. Essentially, we are taking enough probability mass out of the kill radius to return $m$ to its 1999 to 2003 value and putting enough probability mass in the annulus between the kill and wound radii for $h$ to take its actual value. (Recall that this is only single-shot marksmanship and effort. Effort may also have increased the rate of multiple shootings.)

Table 9A.3 summarizes the results of these calculations. Each entry in the table gives the difference between the number of gun homicides that would have occurred in a particular year under a particular counterfactual scenario and the number that actually occurred. The final line gives the difference between gun homicides in the particular year and average gun homicides in 1999 to 2003; it is the reduction that would have been achieved if nothing had changed. We have included a line "other and interaction" to reflect the fact that we have not experimented with changes in $h$ and that the system is nonlinear so that there is no expectation that the sum of individual effects should equal the total effect. But for the most part, the sum of individual effects comes close to the total effect.

**Table 9A.3     Attribution of increase in gun homicides over 1999–2003
(number of gunshot homicides per year)**

|  | Including shots fired | | | | Excluding shots fired | | | |
|---|---|---|---|---|---|---|---|---|
|  | 2004 | 2005 | 2006 | 2007 | 2004 | 2005 | 2006 | 2007 |
| Marksmanship and effort | 2.6 | 7.0 | 9.4 | 2.5 | 5.9 | 8.0 | 8.9 | 5.9 |
| Caliber | 2.4 | 6.3 | 2.7 | 7.1 | 0.3 | 6.3 | 2.7 | 2.1 |
| Single-shot lethality | 5.0 | 13.3 | 12.1 | 9.6 | 6.2 | 14.3 | 11.6 | 8.0 |
| Multiple shots | 8.5 | 12.1 | 4.5 | 21.6 | –0.1 | 2.9 | 4.5 | 15.2 |
| Shootings | 12.6 | 19.5 | 18.2 | 0.2 | 12.3 | 20.8 | 22.1 | 8.8 |
| Other and interaction | –0.3 | –5.1 | 7.0 | 4.4 | 7.4 | 1.8 | 3.6 | 3.8 |
| Total change | 25.8 | 39.8 | 41.8 | 35.8 | 25.8 | 39.8 | 41.8 | 35.8 |

The surprising results on multiple shots when shots fired are excluded are due almost entirely to 1999, which we have noted is not entirely trustworthy. Excluding 1999 and using 2000 to 2003 as the base period instead changes the multiple-shots results to look very similar to the results when shots fired are included.

The outstanding conclusion from table 9A.3 is that everything contributed to the increase in gun homicides. Caliber appears to be the least important, but it still is responsible for as many as six additional homicides in 2005 and nine in 2007. Multiple shots seem to be much more important in 2007 than it was in previous years.

We have some independent confirmation that these estimates are reasonable. For most gun homicides, the NPD learns the caliber of the weapon involved. Generally, higher caliber weapons are more common in more recent years. Zimring (1972) provides old estimates of the relative single-shot lethality of weapons of differing caliber. In an earlier version of this paper, we used somewhat arbitrary extensions of Zimring's conclusions to modern guns and calculated the change in single-shot lethality that the change in composition of guns the NPD was seeing would imply. The estimates were comfortingly similar to the changes in $m$ that our caliber scenario implied.

# References

Adler, Jeffrey S. 2006. *First in violence, deepest in dirt: Homicide in Chicago, 1875–1920.* Cambridge, MA: Harvard University Press.

Aldy, Joseph, and Kip Viscusi. 2003. The value of a statistical life: A critical review of market estimates throughout the world. NBER Working Paper no. 9487. Cambridge, MA: National Bureau of Economic Research.

Baliga, Sandeep, David O. Lucca, and Tomas Sjöström. 2007. Domestic political

survival and international conflict: Is democracy good for peace? Northwestern University. Unpublished Manuscript.

Baliga, Sandeep, and Tomas Sjöström. 2004. Arms races and negotiations. *Review of Economic Studies* 71 (2): 351–69.

Basu, Kaushik. 2006. Racial conflict and the malignancy of identity. *Journal of Economic Inequality* 3:221–41.

Becker, Gary, Kevin Murphy, and Michael Grossman. 2006. The market for illegal goods: The case of drugs. *Journal of Political Economy* 114 (1): 38–60.

Blumstein, Alfred, Frederick P. Rivara, and Richard Rosenfeld. 2000. The rise and decline of homicide—and why. *Annual Review of Public Health* 21:505–41.

Bowker, Lee H. 1981. Crime and the use of prisons in the United States: A time-series analysis. *Criminology* 27:206–12.

Braga, Anthony, David M. Kennedy, Elin J. Waring, and Anne M. Piehl. 2001. Problem-oriented policing, youth violence, and deterrence: An evaluation of Boston's Operation Ceasefire. *Journal of Research in Crime and Delinquency* 38: 195–225.

Cohen, Lawrence E., and Kenneth C. Land. 1987. Age structure and crime: Symmetry versus asymmetry and the projection of crime rates through the 1990s. *American Sociological Review* 52:170–83.

Cook, Philip J. 1983. The influence of gun availability on violent crime patterns. *Crime and Justice* 4:49–89.

Cook, Philip J., and Jens Ludwig. 2006. Aiming for evidence-based gun policy. *Journal of Policy Analysis and Management* 25 (3): 691–736.

Cook, Philip J., Jens Ludwig, Sudhir Venkatesh, and Anthony Braga. 2005. Underground gun markets. NBER Working Paper no. 11737. Cambridge, MA: National Bureau of Economic Research.

Cook, Philip J., and Gary A. Zarkin. 1985. Crime and the business cycle. *Journal of Legal Studies* 14 (1): 115–28.

Corman, Hope, and H. Naci Mocan. 2000. A times series analysis of crime, deterrence, and drug abuse in New York City. *American Economic Review* 90 (3): 584–604.

———. 2005. Carrots, sticks, and broken windows. *Journal of Law and Economics* 48 (1): 235–66.

Detre, Katherine, and Colin White. 1970. Note: The comparison of two Poisson-distributed observations. *Biometrics* 26 (4): 851–54.

Devine, Joel A., Joseph F. Sheley, and M. Dwayne Smith. 1988. Macroeconomic and social-control policy influences on crime rate changes 1948–1985. *American Sociological Review* 53:407–20.

Dezhbaksh, Hashem, Paul H. Rubin, and Joanna M. Shepherd. 2003. Does capital punishment have a deterrent effect? New evidence from postmoratorium panel data. *American Law and Economics Review* 5 (1): 344–77.

Dezhbaksh, Hashem, and Joanna M. Shepherd. 2006. The deterrent effect of capital punishment: Evidence from a "judicial experiment." *Economic Inquiry* 44 (3): 512–35.

Fisz, M. 1955. The limit distribution of a random variable which is a difference of two independent Poisson variables. *Colloquium Mathematica* 3:138–46.

Freeman, Scott, Jeffrey Grogger and Jon Sonstelie. 1996. The spatial concentration of crime. *Journal of Urban Economics* 40 (2): 216–31.

Gaviria, Alejandro. 2000. Increasing returns and the evolution of violent crime: The case of Colombia. *Journal of Development Economics* 61:1–25.

Glaeser, Edward L., and Bruce Sacerdote. 1996. Crime and social interactions. *Quarterly Journal of Economics* 111 (2): 507–48.

Glaeser, Edward L., Bruce I. Sacerdote, and Jose A. Scheinkman. 2003. The social multiplier. *Journal of the European Economic Association* 1 (2–3): 345–53.

Goldin, Claudia, and Lawrence Katz. 2002. The power of the pill: Oral contraceptives and women's career and marriage decisions. *Journal of Political Economy* 110 (4): 730–70.

Harcourt, Bernard E., and Jens Ludwig. 2006. Broken windows: New evidence from New York City and a five-city social experiment. *University of Chicago Law Review* 73 (1): 271–320.

Harrison, Paige M., and Allan J. Beck. 2007. Prisoners in 2005. Bureau of Justice Statistics Bulletin. http://www.ojp.usdoj.gov/bjs/abstract/p05.htm.

Katz, Lawrence, Steven D. Levitt, and Ellen Shustorovich. 2003. Prison conditions, capital punishment, and deterrence. *American Law and Economics Review* 5 (2): 318–43.

Kelling, George L., and William H. Sousa Jr. 2001. Do police matter? An analysis of New York City's police reforms. Manhattan Institute Civic Report no. 22. www.manhattan-institute.org/html/cr_22.htm.

Kennedy, David M., Anthony Braga, Anne M. Piehl, and Elin J. Waring. 2001. Reducing gun violence: The Boston Gun Project's Operation Ceasefire. Washington, DC: National Institute of Justice.

Kleinknecht, William, and Jonathan Schuppe. 2006. Getting away with murder. *Newark Star-Ledger,* January 29, 30, and 31. www.nj.com/news/murder.

Levitt, Steven D. 1996. The effect of prison population size on crime rates: Evidence from prison overcrowding litigation. *Quarterly Journal of Economics* 111 (2): 319–51.

———. 1998. Why do increased arrest rates appear to reduce crime: Deterrence, incapacitation, or measurement error? *Economic Inquiry* 36 (3): 353–72.

———. 2002. Using electoral cycles in police hiring to estimate the effects of police on crime: Reply. *American Economic Review* 92 (4): 1244–50.

———. 2004. Understanding why crime fell in the 1990s: Four factors that explain the decline and six that do not. *Journal of Economic Perspectives* 18 (1): 163–90.

Levitt, Steven D., and Sudhir Venkatesh. 2000. An economic analysis of a drug-selling gang's finances. *Quarterly Journal of Economics* 115 (3): 755–89.

Marvell, Thomas, and Carlisle Moody. 1994. Prison population and crime reduction. *Journal of Quantitative Criminology* 10:109–39.

———. 1997. The impact of prison growth on homicide. *Homicide Studies* 1 (3): 205–33.

Minino, Arialdi, Robert N. Anderson, Lois A. Fingerhut, Manon A. Boudreault, and Margaret Warner. 2006. Deaths: Injuries, 2002. National Vital Statistics Reports no. 54 (10). National Center for Health Statistics, Centers for Disease Control and Prevention. www.cdc.gov/nchs.deaths.htm.

Miron, Jeffrey A. 1999. Violence and U.S. prohibitions on drugs and alcohol. *American Law and Economics Review* 1:78–114.

———. 2001. Violence, guns, and drugs: A cross-country analysis. *Journal of Law and Economics* 44 (2): 615–34.

O'Flaherty, Brendan. 1998. Why repeated criminal opportunities matter: A dynamic stochastic analysis of criminal decision-making. *Journal of Law, Economics, and Organization* 14 (2): 232–55.

O'Flaherty, Brendan, and Rajiv Sethi. 2008. Peaceable kingdoms and war zones: Preemption, ballistics and murder in Newark. Columbia University, Department of Economics, Working Paper no. 0708-02.

———. 2010. Witness intimidation. *Journal of Legal Studies,* forthcoming.

Piehl, Anne M., Suzanne J. Cooper, Anthony Braga, and David M. Kennedy. 2003.

Testing for structural breaks in the evaluation of programs. *Review of Economics and Statistics* 85:550–58.

Raphael, Steven, and Jens Ludwig. 2003. Prison sentence enhancements: The case of Project Exile. In Evaluating gun policy: Effects on crime and violence, ed. Jens Ludwig and Philip J. Cook, 251–76. Washington, DC: Brookings Institution Press.

Raphael, Steven, and Michael Stoll. 2004. The effect of prison releases on regional crime rates. *Brookings-Wharton Papers on Urban Affairs* 5:207–55.

Raphael, Steven, and Rudolf Winter-Ebmer. 2001. Identifying the effect of unemployment on crime. *Journal of Law and Economics* 44 (1): 259–84.

Rasmusen, Eric. 1996. Stigma and self-fulfilling expectations of criminality. *Journal of Law and Economics* 39:519–43.

Rosenfeld, Richard, Robert Fornango, and Eric Baumer. 2005. Did ceasefire, compstat, and exile reduce homicide? *Criminology and Public Policy* 4 (3): 419–50.

Sah, Raaj. 1991. Social osmosis and patterns of crime. *Journal of Political Economy* 99 (6): 169–217.

Schelling, Thomas C. 1960. *The strategy of conflict.* Cambridge, MA: Harvard University Press.

Schrag, Joel, and Suzanne Scotchmer. 1997. The self-reinforcing nature of crime. *International Review of Law and Economics* 17 (3): 325–35.

Swersey, Arthur J. 1980. A greater intent to kill: The changing pattern of homicide in Harlem and New York City. Yale University School of Management. Unpublished Manuscript.

Wilson, James Q., and George Kelling. 1982. Broken windows. *Atlantic Monthly* 249 (3): 29–38.

Zimring, Franklin. 1972. The medium is the message: Firearm caliber as a determinant of death from assault. *Journal of Legal Studies* 1 (1): 97–123.

Zimring, Franklin, and Gordon Hawkins. 1995. *Incapacitation and the restraint of crime.* New York: Oxford University Press.

## Comment    Guillermo Cruces

### Introduction

O'Flaherty and Sethi's study "Peaceable Kingdoms and War Zones: Preemption, Ballistics, and Murder in Newark" is a work of extensive breadth that makes a valuable contribution by incorporating game-theoretic social interactions to the economics of murder. Starting from recent evidence on an increasing trend in murders in Newark and other urban areas in New Jersey at the time of a generalized fall in aggregate U.S. trends, the paper turns to a detailed decomposition of gun discharge episodes, unearthing a puzzling stylized fact: murders rose much faster than shootings in Newark. The authors develop a game-theoretical model to explain this increase in lethality and to account for the differing New Jersey and U.S. trends simul-

Guillermo Cruces is deputy director of the Center for Distributive, Labor, and Social Studies (CEDLAS) at the Universidad Nacional de La Plata.