How Large Should the Strike Zone Be in “Three Strikes and You’re Out” Sentencing Laws?

Jonathan P. Caulkins
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213-3890 USA

Abstract
So-called “three strikes and you’re out” sentencing laws for criminal offenders have proliferated in the United States in the 1990s. The laws vary considerably in their definitions of what constitutes a “strike”. This paper adapts the classic Poisson Process model of criminal offending to investigate how varying sentence lengths and definitions of what constitutes a strike affect the effectiveness and cost-effectiveness of these sentencing laws. In particular, it asks whether by using different definitions for the first, second, and third strikes or different sentence lengths, one can make the resulting incarceration more “efficient” in the sense of incapacitating more crimes per cell-year served.

Introduction

Controlling crime is a perennial concern. Increasingly, controlling the size of the burgeoning prison population and associated its costs is as well. Hence, it is desirable to design criminal justice policies to be efficient, in the sense of averting as many crimes per cell-year or per dollar spent as possible. The quest for efficiency should not, of course, eclipse considerations of justice and due process, but the costs to society of both crime and crime control are large enough to warrant analysis and careful management.

In that vein, this paper asks how so-called “Three Strikes and You’re Out” laws should be designed. These laws mandate very long sentences for people who are convicted three times.[1] The first and second convictions typically also result in punishment, but of a more routine character. The name derives from the obvious analogy in American baseball, and these laws appeal to a certain intuitive notion of justice. Everyone is allowed to foul up once, even twice, but three-time offenders forfeit their right to be rehabilitated and are given very long sentences, up to life imprisonment. These laws have sufficient appeal that some type of three strikes law is now on the books in about half the states and in the federal sentencing system (Clark et al., 1997).

At first blush it would seem that there is little to design or optimize with three strikes laws. The sentences for the first, second, and third strikes are short, “enhanced”, and approximately infinite, respectively. What more does one need to know?

It turns out that considerable design latitude remains. For example, Greenwood et al. (1994) show that the second strike provisions can play as great a role in the costs and effectiveness of California’s three strikes law as the notorious “25 year to life” third strike provision, in part because more people receive second strikes than third strikes.

Here the focus is on another issue, namely which offenses constitute “strikes”. To illustrate the distinction, consider in contrast the California and Pennsylvania State laws. California law generally (not the three-strikes law in particular) differentiates between violent offenses, serious offenses that are not also violent, and all other felonies. Roughly speaking, violent offenses are those involving physical injury (primarily murder, rape, robberies and aggravated assaults involving bodily injury or a firearm pursuant to certain penal codes). Serious offenses include some other types of robbery and aggravated assault as well as residential burglary. The other category includes burglary of commercial establishments, theft, motor vehicle theft, fraud, etc.

---

[1] There are variations. Maryland has special sanctions for fourth strikes. Georgia has what amounts to a “two strikes and you’re out” law.

In California the first two strikes must be serious or violent offenses. The third, however, can be any felony. This means that the California statute casts a broad net, potentially affecting thousands of offenders per year. Greenwood et al. (1994) estimate that if it were fully implemented (which it has not been), the California Three Strikes law could roughly double the prison population relative to what it would have been without the law.

The Pennsylvania State statute, in contrast, only counts as strikes crimes such as murder, rape, kidnapping, robbery, and aggravated assault, roughly what California calls “violent” offenses. There are about two-and-a-half times as many serious as violent crimes, by the California definition, and far more “other” crimes. Hence, a statute following the Pennsylvania model will affect a much smaller and more selective group of offenders. Indeed, California sanctions about 10,000 offenders per year under its law (roughly 90% for second strike provisions). In contrast, eighteen states that implemented three-strike laws in 1994 or 1995 had ten or fewer three-strike convictions as of September, 1996 (Greenwood et al., forthcoming).

From an incapacitative perspective one would expect laws such as the one in Pennsylvania to be more cost-effective than laws such as the one in California because their targeting should stochastically select high-rate offenders to receive disproportionately the very long sentences. At the same time they would inevitably be less effective in the sense of having a more modest impact on crime.

A central question addressed in this paper is how the definition of what constitutes a strike at each stage affects the effectiveness and cost-effectiveness of three-strike laws. Using California’s distinction between violent, serious but not violent, and other felonies, one can imagine a matrix with a column for each crime-type and a row for each number of prior strikes. Each cell in the matrix indicates whether the crime does or does not count as an additional strike. Naturally more refined categorizations are possible (e.g., differentiating homicide from manslaughter), but the goal of this paper is only to provide general qualitative insights not to generate precise quantitative estimates. Greenwood et al. (1994) estimate the cost-effectiveness of two extreme strike definitions (the California law and a hypothetical scheme in which California only counted violent offenses as strikes, akin to Pennsylvania’s law), but did not systematically explore the intermediate options.

Before proceeding to the model, it is important to identify several limitations of the analysis. First, the analysis considers only incapacitative effects of incarceration. It ignores both deterrence and any rehabilitative (or “hardening”) effects of prison. The reason is primarily lack of data with which to parameterize these effects. It is not clear whether deterrence or rehabilitation contribute substantially to the effectiveness and cost-effectiveness of three strike laws. In the past these mechanisms were sometimes dismissed as of second-order importance because empirical efforts to measure them have generally yielded weak and/or ambiguous results. However, three strike laws are not like other sentencing laws in a variety of respects, so they might deter or rehabilitate even if routine sentencing enhancements do not.

Second, the model of offending underlying the analysis is a highly simplified one. It is the workhorse of quantitative analyses of sentencing interventions (Maltz, 1994), but that does not mean it is as valid as, for example, models of more easily observable systems such as queues and inventories. For example, the model does not consider the possibility that an individual’s average offense rate might vary over the course of his or her career.

Third, the notions of effectiveness and cost-effectiveness considered here are aggregate ones. No effort is made to identify differential effects by race, gender, age or any other category.

Fourth, the focus is on non-drug offenses, even though drug-law offenders comprise an increasing proportion of those incarcerated. Drug law violations have their own sets of mandatory sentencing laws (Caulkins et al., 1997). The laws interact. For example, the third strike in California can be conviction for a drug felony. But drug violators are not the unique focus of most three-strike laws.

Fifth, to some extent the conclusions are California-specific. The parameters are patterned after California data because the California law is the “largest” by most metrics and because the California law has motivated the most prior research. Different states are different, however, so replicating the analysis with parameters appropriate for other states would be informative. That is beyond the scope of the current paper, but since the underlying model (as opposed to the parameter values) is general, it could be done.

Sixth, the model in no way considers the effects of selective application of the laws by prosecutors, which could change the cost-effectiveness in either direction, depending on how skillful prosecutors are at targeting high rate offenders.

2.0 Model

To model how a sentencing policy affects the number of people incarcerated and the number of crimes averted through incapacitation, one needs a model of criminal offending. There is enormous heterogeneity both across offenders and over time for a particular offender, but it is generally accepted that modeling aggregate crime commission by a population of offenders with a Poisson Process is a workable approximation. This approach was pioneered by Shinnar and Shinnar (1975), and has been applied repeatedly since then.

This model assumes that active offenders on the street commit crimes at a Poisson rate λ per year. Each arrest has a fixed probability, q, of leading to conviction and incarceration for S years.[2] Offenders are assumed not to commit crimes against the general public while they are incarcerated. The crimes they would have committed had they been on the street represent the crimes averted through incapacitation.

When prison sentences are not short relative to career lengths, it is necessary to model the criminals' career lengths explicitly. Driven in no small part by concerns of tractability, we follow the lead of Barnett and Lofaso (1986) by assuming that the length of criminal careers are exponentially distributed with mean $1/\delta$ independent of punishment (i.e., there is no "specific deterrence"). This implies that, while free, the next "event" in a criminal's career is determined by a competing Poisson Process model. With probability $\delta/(\delta + \lambda)$ the next event is retirement (assumed to be permanent). With probability $\lambda q/(\delta + \lambda)$ the next event is an offense that leads to conviction (assumed to occur immediately after the offense). And with probability $\lambda(1 - q)/(\delta + \lambda)$ the next event is an offense that does not lead to punishment, which leaves the offender free, active, and awaiting the next "event" in his or her career. Likewise, if conviction always leads to incarceration for a time S, the probability the offender retires before being released is $1 - e^{-\delta S}$, and with probability $e^{-\delta S}$ the released offender returns to a life of crime. As Barnett and Lofaso (1986) show, together these assumptions imply that the expected number of crimes committed over a criminal's career is $N = \lambda / (\delta + \lambda q (1 - e^{-\delta S}))$.

Often it is sufficient to define the offender's state as being "free and active", "retired", or "incarcerated", sometimes distinguishing among incarcerated offenders who would be active if they were free and those who would have already retired. When modeling repeat offender laws, this state description must be augmented by an indication of the length of the offender's criminal history. With three strikes laws in particular, it is useful to distinguish among free and incarcerated offenders who have zero, one, two, and three or more prior strikes.

Hence, one additional parameter is needed to adapt the basic Poisson model to the present application. Let ϕ_i be the probability that a conviction counts as a strike given that the offender is in state i (i.e., has i prior strikes). Since laws often indicate unequivocally whether a crime counts as a strike or not, the ϕ_i's may typically be either 0 or 1, but allowing intermediate values does not complicate the analysis.

Figure 1 shows the resulting Markov model, where crime-type specific offense rates have been aggregated into an overall offense rate λ to avoid cluttering the chart. It differs from the usual Markov diagram in one respect. Since time served is modeled as a fixed constant, S, not an exponentially distributed quantity, transitions out of incarcerated states do not occur according to a Poisson process. Rather, those transitions always occur after exactly S units of time, and the arc labels simply indicate the probability that the arc is taken. They are drawn with dotted lines to differentiate them from the Poisson flow rate arcs emanating from the free states.

Figure 1 About Here

[2] For other applications, the probability of incarceration given offense is broken down into a probability of incarceration given conviction, probability of conviction given arrest, and a probability of arrest given offense. Likewise, it is sometimes important to distinguish between jail and prison sentences and to break expected time incarcerated into expected sentence and percentage of sentenced time actually served. We only discuss and use here the portions of the Poisson model of criminal offending that are needed for present purposes. Furthermore, we assume that all convictions are followed by some incarceration.

The quantities of interest are the expected number of crimes committed and the expected time spent incarcerated per career. Both can be found easily from the expected time spent in each of the "free and active on the street" states. Because this is a Markov model, expected time spent in each of those states can be found as:

Expected time in state = Expected time to leave + P{return | leave} * Expected time in state

so

Expected time in state = Expected time to leave / (1 – P{return | leave}). (1)

Exits from the free and active state occur through retirement (at rate δ) and committing crimes that lead to conviction (at rate λq), so the expected time to leave is just 1/(δ + λq). Exits lead to a return to the same state if and only if the exit is by committing a crime and being convicted, the crime does not add to the number of strikes, and the offender does not retire while incarcerated. That occurs with probability λ q (1 – ϕ) $e^{-\delta S}$ / (δ + λq). Likewise, the probability that an offender becomes free and active with j +1 strikes given that he or she was ever free and active with j strikes is λ q ϕ_j $e^{-\delta S j+1}$ / (δ + λq – λ q (1 – ϕ_j) $e^{-\delta S j}$).

Subscripting the type of crime by i and both time served (S) and the probability the offense counts as a strike (ϕ) by j, to denote the number of prior strikes, these equations can be generalized to

$$Expected\ time\ to\ leave\ state\ j = \frac{1}{d + \sum_{i=other}^{violent} l_i q_i}$$

$$P\{return\ to\ state\ j \,|\, leave\} = \frac{\sum_{i=other}^{violent} l_i q_i e^{-d S_i^j}\left(1 - f_i^j\right)}{d + \sum_{i=other}^{violent} l_i q_i}$$

$$P\{enter\ state\ j+1 \,|\, in\ state\ j\} = \frac{\sum_{i=other}^{violent} l_i q_i e^{-d S_i^{j+1}} f_i^j}{d + \sum_{i=other}^{violent} l_i q_i - l_i q_i e^{-d S_i^j}\left(1 - f_i^j\right)}$$

These equations were implemented in an Excel spreadsheet with a row for each type of offender (defined by offense rates, desistance rate, and proportion of criminals that belong to that type). Aggregate results were found by taking weighted averages across the rows. The spreadsheet allows the offense and desistance rates to depend on the number of prior strikes. This might be useful for modeling deterrent effects, but is not pursued here because of a lack of data for specifying the relevant parameters.

3.0 Parameters

3.1 Sentencing Parameters

Greenwood et al. (1994) report convictions (p.57) and offenses (p.56) by FBI index crime type. Adding these up according to the proportion of index crimes that are violent, serious but not violent, or other (p.46), dividing, and rounding to three places gives probabilities of conviction per offense of 6.3%, 4.5%, and 2.1% for violent, serious but not violent, and other index crimes, respectively.

Greenwood et al.'s assumptions about the expected time served per conviction before and after the Three Strikes Law as a function of the number of prior strikes can be calculated from the parameters in their spreadsheet model. The results are given in Table 1.

Table 1: Expected Time Served Given Conviction in California as a Function of the Number of Prior Strikes

	California Before Its Three Strikes Law			California's Three Strikes Law		
# of Prior Strikes	Other	Serious, not V	Violent	Other	Serious, not V	Violent
0	0.39	0.48	0.74	0.39	0.48	0.74
1	0.61	1.13	1.03	1.67	10	10
2+	0.82	1.79	1.92	20	20	20

In the present model, we need the expected sentence as a function of the number of strikes including the current offense. In most cases this simply involves shifting the row label in the table by one. For example, if someone commits a violent offense and their strike total at sentencing were three, then the sentence is the same as that given in the table above when the number of prior strikes is two. The exceptions are driven by the rules governing which offenses count as strikes. Under the California law, all offenses are strikes except for "other" felonies committed when the offender has zero or one prior strike. (The previous California law actually had repeat offender provisions, and Greenwood et al. (1994) modeled their structure as not dissimilar from the three strikes law, but as the table shows, the magnitude of the sentence enhancements was modest.)

The first exception is that in California there is no such thing as an expected sentence for a serious or violent crime given that the defendant has no strikes at the time of sentencing because the serious or violent offense itself is always a strike. However, we would like to investigate alternative definitions of strikes, including those for which the first strike must be violent, so we need to fill in at least the expected sentence for a serious offense with no strikes. We do this by using the expected sentences when the number of prior strikes is 0. That is natural and of little consequence.

The second exception is trickier. In California there is no such thing as a sentence for an "other" felony that is the second strike (including that crime). If the individual previously had one strike, the current "other" felony would not count as a strike, so the strike count at sentencing is one. If the individual previously had two strikes, the current felony would count as the third strike. We fill in this gap in the table by taking the geometric mean of the expected sentences when there is one more or one less prior strike. Thus, our table of expected sentences as a function of the number of strikes including the current offense is as follows (imputed values in italic):

Table 2: Sentences Given Conviction Used in Present Model

	California Before Its Three Strikes Law			California's Three Strikes Law		
# of Strikes at Sentencing	Other	Serious, not V	Violent	Other	Serious, not V	Violent
0	0.39	*0.48*	*0.74*	0.39	*0.48*	*0.74*
1	0.61	0.48	0.74	1.67	0.48	0.74
2+	*0.71*	1.13	1.03	*5.78*	10	10
3+	0.82	1.79	1.92	20	20	20

3.2 Descriptions of the Criminal Population

The original Greenwood et al. (1994) Three Strikes study divided offenders into two groups: low- and high-rate offenders. High-rate offenders were those with offense rates above the median offense rate among those incarcerated in 1993 (the base year for parameter estimates). Eighty-percent of new offenders are low-rate offenders (p.67), but high-rate offenders are over-represented in prison because they remain active twice as long on average (20 years vs. 10 years, p.55) and have average annual offense rates that are 17.52 times greater than low-rate offenders (p.17).

Table 3: Greenwood et al. (1994) Model of the Offender Population

	Proportion of Offender Population	Crimes per Offender per Year			Desistance Rate
		Other	Serious, not V	Violent	
Low-rate offenders	80%	0.37	0.16	0.08	0.1
High-rate offenders	20%	6.47	2.81	1.32	0.05

Distinguishing between low and high rate offenders is important because there is considerable heterogeneity in offense rates (Chaiken and Chaiken, 1982). Indeed, a two-population model is only a crude approximation, so here we adapt the continuous distribution of average annual offense rates for California robbers reported by Blumstein et al. (1993). We break that continuous distribution into 25 discrete groups. For each group, the Blumstein et al. offense rate for the median offender within the group is calculated and assigned to the group as a whole. These overall offense rates were distributed across the minor, serious, and violent offense categories and scaled proportionally so that the average offense rate and distribution across categories matched that in Greenwood et al. Likewise, the retirement rate (0.055 per year) was selected to make the expected number of offenses over the average criminal's career, assuming no incarceration, 47.2, the same as in the Greenwood et al. study. This scaling makes the numbers produced here more comparable with those in the original three-strikes study. The final distribution is given in Table 4.

Table 4: Base Model of Offenders.

Group	Proportion of Offender Population	Minor Offense Rate	Serious but not Violent Offense Rate	Violent Offense Rate
1	20%	0.089	0.038	0.018
2	10%	0.244	0.106	0.050
3	10%	0.368	0.160	0.075
4	10%	0.516	0.224	0.105
5	10%	0.698	0.302	0.142
6	5.0%	0.868	0.377	0.177
7	5.0%	1.007	0.437	0.205
8	5.0%	1.175	0.509	0.239
9	5.0%	1.387	0.601	0.283
10	2.5%	1.592	0.690	0.325
11	2.5%	1.765	0.765	0.360
12	2.5%	1.982	0.859	0.404
13	2.5%	2.272	0.985	0.463
14	2.5%	2.703	1.172	0.551
15	1.0%	3.184	1.380	0.649
16	1.0%	3.598	1.560	0.733
17	1.0%	4.208	1.824	0.858
18	1.0%	5.167	2.240	1.053
19	1.0%	6.699	2.904	1.365
20	0.50%	8.457	3.666	1.724
21	0.50%	10.172	4.410	2.073
22	0.50%	12.870	5.580	2.623
23	0.50%	19.122	8.290	3.898
24	0.25%	49.703	21.549	10.130
25	0.25%	121.685	52.757	24.802

The Greenwood et al. model assumes the average offense rate for high-rate offenders is 17.52 times larger than the corresponding rate for low-rate offenders for all types of crime (violent, serious but not violent, and other) (p.55). It is possible, however, that this ratio is greater for serious and violent crimes than for other index offenses. That is, perhaps high-rate offenders not only commit more crimes but also commit a more serious mix of crimes. To consider this, we modify the distribution above by dividing in half the offense rates for serious and violent crimes for the 80% of offenders with the lowest overall offense rates, and increasing the corresponding rates for the other offenders enough (by 17.9%) to leave the average offense rates unchanged. There is no empirical basis for the magnitude of this adjustment. It is simply an exploratory sensitivity analysis.

4.0 Results

4.1 How Strike Definitions Affect Effectiveness and Cost-Effectiveness

With three types of crime (minor, serious, and violent), three-strikes law's definitions of strikes can be characterized with a 3X3 matrix of 0's and 1's indicating whether a particular type of offense counts as a strike given a particular number of priors. Table 5 illustrates such a matrix for California. Serious and violent offenses always count as strikes. Convictions for minor offenses can generate a third strike, but not a first or second strike.

Table 5: California's Strike Definitions; 1 = yes, 0 = no

# of Prior Strikes	Other (Minor) Offenses	Serious but not Violent Offenses	Violent Offenses
0	0	1	1
1	0	1	1
2	1	1	1

Since there are nine cells, in principle there are $2^9 = 512$ possible patterns. Fortunately, not all need to be evaluated. At least one offense must count as a strike in each row, or there would be no way for anyone to get three strikes. Presumably, if some offense can count as a strike, a violent offense would, so only patterns with all 1's in the third (violent offense) column are considered.

Conversely, the California pattern is noteworthy for having cast a very broad net. So broad, in fact, that the law was not implemented as written. So we take the California scheme as anchoring the end of the range of schemes considered here, and do not consider schemes in which a minor offense can count as a first or second strike.[3]

Thus only $2^4 = 16$ schemes are considered here. They will be denoted by a triplet, $<x_0, x_1, x_2>$, where x_i indicates the type of offense that counts as a strike when the offender has i prior strikes. For example, <V, SV, Any> denotes a law under which only violent offenses count as first strikes, serious and violent offenses count as second strikes, and any felony counts toward the third strike. Some of the 16 schemes have strikes triggered by minor or violent offenses but not serious offenses. These will be denoted by MV and are listed below even though they are not likely to be implemented because it seems perverse to count minor but not serious offenses as strikes.

Table 6 summarizes the model results for each of these sixteen schemes relative to the results with the pre-three strikes sentencing policy. The results are undiscounted, expected outcomes over the career of an average offender. Criminal justice system (CJS) cost is crudely proxied by $25,000 times the number of cell-years plus $2,000 times the number of convictions.[4] That the number of convictions in the

[3] Some runs were done of schemes in which convictions for minor offenses counted as first or second strikes. As one might expect, expanding the net by broadening the strike definition for first and second strikes led to greater impacts on crime but lower cost-effectiveness.

[4] Greenwood et al. (1994) assumed that prison cost about $25,000 per cell-year, including capital costs, and that police and non-trial adjudication costs under basecase conditions were about $2,000 per arrest. Since not all arrests result in conviction and some convictions are obtained through trial, the $2,000 per conviction figure used here is probably too low. However, since average criminal justice costs per

baseline scenario is 1.0 is a coincidence; there was no normalization to force that number to be 1.0. Asterisks in the "Policy" column denote policies that do not violate the notions that more serious offenses should count as strikes if lesser offenses do and that an offense should count as a strike with a given number of priors if it counts as a strike with fewer priors.

Table 6: Expected Outcomes per Criminal Career with Various Strike Definitions

Policy	Total Crimes	Serious and Violent Crimes	Convictions	Years in Prison	CJS Cost per S&V Crime Averted
Baseline	30.7	11.9	1.00	0.87	NA
V, V, V*	27.9	10.9	0.91	1.37	$ 11,115
V, V, SV*	27.7	10.8	0.90	1.43	$ 12,077
V, V, MV	27.7	10.8	0.90	1.45	$ 12,165
V, V, Any*	27.6	10.7	0.90	1.49	$ 12,732
V, SV, V	26.3	10.2	0.86	1.77	$ 12,890
V, SV, SV*	26.1	10.2	0.85	1.87	$ 13,834
V, SV, MV	26.0	10.1	0.85	1.90	$ 13,935
V, SV, Any*	25.9	10.1	0.84	1.97	$ 14,511
SV, V, V	25.9	10.1	0.85	1.83	$ 12,804
SV, V, SV	25.8	10.0	0.84	1.94	$ 13,684
SV, V, MV	25.7	10.0	0.84	1.96	$ 13,783
SV, V, Any	25.6	10.0	0.83	2.03	$ 14,323
SV, SV, V	23.6	9.2	0.77	2.53	$ 14,893
SV, SV, SV*	23.4	9.1	0.76	2.70	$ 15,828
SV, SV, MV	23.2	9.0	0.76	2.74	$ 15,945
SV, SV, Any*	23.1	9.0	0.75	2.85	$ 16,534

As expected, the narrowest definition of what constitutes a strike (V, V, V; as in Pennsylvania) yields the smallest reduction in crime but the lowest cost per serious or violent crime averted. The broadest definition of what constitutes a strike (Serious, Serious, Any; as in California) yields the greatest reduction in crime and the lowest cost-effectiveness. The cost-effectiveness of these two alternatives is very close to what Greenwood et al. (1994, p.26) estimated for those options ($11,115 vs. $11,800 for V,V,V and $16,534 vs. $16,300 for Serious, Serious, Any, respectively). Indeed, given that the model in this paper does not reproduce the many details of the Greenwood et al. model, the agreement is closer than one has a right to expect.

The basic story in Table 6 is that the broader the definition of what constitutes a strike, the greater the reduction in crime but the greater the cost per crime averted. The greater the scope and impact of the law, the less focused it is and, hence, the less cost-effective.

Figure 2 shows this graphically, plotting the reduction in serious and violent crimes against the increase in criminal justice costs. The circles correspond to the rows of the table above. The diamonds are the result of parallel runs with the alternative description of the offender population, in which low-rate offenders are differentially less likely than high-rate offenders to commit serious and violent crimes. When there is a correlation between offense rate and offense seriousness, these repeat-offender laws are more cost-effective at reducing serious and violent crime. But the pattern of decreasing efficiency with increasing scope persists.

Figure 2 About here.

Across these two models of the offender population, moving from a narrow (Pennsylvania style) to a broad (California) definition of what constitutes a strike increases the crime reduction relative to

---

offender are always at least $35,000 and there is never more than one conviction on average, prison costs dominate these calculations.

baseline by a factor of 2.5-2.7. However, the increase in criminal justice system costs expands by a factor of 3.5 to 4.0, and the cost per crime averted increases by a factor of 1.4 – 1.5.

The sixteen variants do not smoothly fill in the entire curve between the end points. There are three clusters, determined by the definitions of the first two strikes. Schemes that require both of the first two strikes to be violent form the left-most cluster. Schemes that allow both to be serious or violent form the right-most cluster. Schemes that follow a Violent-Serious-X or a Serious-Violent-X pattern form the middle group. However, it is certainly not the case that the examples offered by California and Pennsylvania represent the only possibilities. For any desired reduction in offending between the two extremes, there is some scheme that is predicted to yield a reduction that is within 18% of the desired value. So rather than imagining that a state must choose between a very broad or a very narrow law, it is more accurate to think in terms of being able to choose from along an efficient frontier of alternatives that trade off efficiency and scope.

4.2 How Sentence Length Affects Effectiveness and Cost-Effectiveness

The previous section considered how the definition of what constitutes a strike affects the effectiveness and cost-effectiveness of a three-strike law when the sentence lengths as a function of the number of strikes are given (and, in particular, are like those of the California Three Strikes law). The symmetric question is, for a given definition of what constitutes a strike, what sentences are most effective and cost-effective at reducing crime?

Since California had the same definition of what constitutes a strike both before and after passage of its three strikes law, we focus initially on that strike definition (described in Table 5). Unconstrained optimization suggests that the most cost-effective sentencing strategy would be to let first and second strike offenders go free and punish third strike offenders with very brief sentences. Since California's Three Strikes law was passed in order to "get tough" on crime, such solutions are not politically feasible or relevant. So the optimization question was rephrased to be: given the strike definition, what is the least expensive way to reduce the expected number of serious and violent crimes per offender by a given amount, constraining sentences to be no shorter than they have been in the past. The answer is most interesting. In all cases investigated, cost-effectiveness declines as sentences grow, so maximizing cost-effectiveness suggests choosing sentences as short as possible.

Initially it is optimal to extend sentences only for those with three strikes, and very quickly it becomes optimal to make the third strike sentence the same regardless of the incident offense. Only when the third strike sentences reach about six years (time served, not sentenced), does it become optimal to begin to extend sentences for those with two strikes. At that point, the expected number of serious and violent crimes per offender has been cut by between 1.5 and 1.75. (By way of comparison, Figure 2 shows that a violent-violent-violent scheme with 20 year third strike sentences reduces these crimes by about 1.1, and the broad California scheme would reduce it by about 3.0.)

If further reductions in crime are desired, the sentences for defendants with two and three strikes are extended, still with no change in sentences for those with fewer strikes. The sentence for those with two strikes is very similar regardless of the incident charge, but is less than that for those with three strikes. Finally, when the desired reduction in crime is around 2.5, it is optimal to begin to extend sentences for those with no prior strikes. Within the model, the optimal way to achieve a reduction of 3.0 serious crimes per offender is to have second and third strike sentences be about half as long (roughly six and ten years, respectively, not ten and twenty), but to have first strike sentences be much longer (1.3-1.7 years vs. 0.4-0.7 in the actual law). (Following Greenwood et al. (1994), the current law's 25-year to life sentences are modeled as involving 20 years actually served, reflecting a 20% credit for good time and an assumption that most offenders will serve the minimum time possible.)

Initially the reductions in crime can be achieved fairly economically ($5,000 per serious or violent crime averted), but the cost per crime averted grows with the magnitude of the desired reduction in crime. To reduce crime by 3.0 serious crimes per offender, the cost per crime averted is $14,300. That is interesting because that figure is only moderately lower than the estimate obtained above for the actual California law. That is, according to the model and given California's broad strike definition, the most cost-effective way to reduce crime by this amount is only 14% more efficient than the actual law would be ($14,300 per crime averted vs. $16,500 per crime averted).

One reaction to this might be that the deterrent and retributive-justice based benefits of the Draconian sentences in the current law are obtained at a fairly modest cost in terms of efficiency. On the other hand, 14% of multiple billions of dollars is not a small sum. Furthermore, the same crime reduction can be obtained at a cost of $14,750 per crime averted if the 20-year sentences are restricted to convictions for violent offenses that are third or subsequent strikes. This option might preserve much of the deterrent and justice benefits while still being 11% more efficient than the current law.

The previous section suggested that laws with a narrower definition of what constitutes a strike might be more cost-effective. So the analysis of optimal sentence lengths for the California scheme was replicated for schemes in which (1) only violent crimes are strikes (the Pennsylvania model) and (2) the first strike must be violent, the second must be serious or violent, and the third can be any crime. Figure 3 shows the resulting additional cost per offender as a function of the reduction in crime per offender.

Figure 3 about here

For small reductions in crime, these two schemes are more cost-effective than the broad definition of what constitutes a strike. Indeed, both of these schemes can reduce crime by about 0.25 crimes per offender relative to baseline at no additional cost. However, they are actually less cost-effective than the broad definition at achieving large reductions in crime. The reason is that they select too small a proportion of the offender population for longer sentences, so in order to generate large reductions in crime, those extended sentences must be very long. Very long sentences are inefficient because criminal careers are not infinite. The longer the sentence, the greater the proportion of sentenced individuals who would have retired before the end of their sentence, the greater the amount of incarceration that is "wasted" from an incapacitative view, and the less cost-effective the sentence.

In some sense, this should be obvious a priori. If one wants to achieve large reductions in crime, it is necessary to use a law that casts a wide net. Trying to achieve such reductions with a more narrow law could backfire. Nevertheless, it was not anticipated a priori that the broad law might be the most cost-effective, or that the most cost-effective pattern of sentence lengths would be only moderately more cost-effective than the California law (indicated with a diamond in Figure 3).

5.0 Discussion

So-called "Three-Strike" laws are a common and costly response to concerns about crime. Some effort has gone into evaluating the effectiveness of the extant laws (e.g., Greenwood et al., forthcoming; Zimring et al., forthcoming). Less thought has been given to how to design these laws to make them more effective and cost-effective.

The central qualitative findings of this paper in that regard are as follows. First, broadening the definition of what constitutes a strike makes the laws more effective in the sense that they take a bigger bite out of crime but less cost-effective in the sense that criminal justice costs to taxpayers per crime averted rise with expanding scope. The choice need not be one made only between polar extremes. Various strike definitions generate almost a continuum of choices along a spectrum between very narrow and very broad laws.

Second, at least for the model of offender behavior used here, the sentences for repeat offenders in the California law are too long from the perspective of efficient crime reduction. Six and ten year sentences for second and third strike offenders, respectively, would be more efficient than the ten and twenty year terms of the current law. On the other hand, it might be more efficient to expand sentences for first strike offenders. In the context of the current model, California's law seems to take a good idea (longer sentences for repeat serious offenders) a bit too far.

Third, it is not obvious from the current analysis that the California Three-Strike law is very poorly designed from an efficiency perspective. It is broad, and more focused laws can be more cost-effective, but they are not necessarily more cost-effective if large amounts of incapacitation are demanded. Furthermore, the model suggests that more efficient, shorter sentences for second and third strike offenders would only cut the cost of reducing crime by about 15%. On the one hand this suggests that the benefits, symbolic and otherwise, of taking an uncompromising tough stand against third strike offenders can be obtained for a modest cost. On the other hand, reserving the longest sentences for violent third strike offenders achieves most of the potential cost savings and so might be a useful intermediate position.

All of these findings must be caveated by the nature and limitations of this analysis. They are derived from a simple, stylized model that reflects only the broadest attributes of criminals and the criminal justice system and which considers only incapacitative effects of incarceration, not deterrence, rehabilitation, or “hardening” of offenders.

References

Barnett, A., and A. J. Lofaso (1986). "On the Optimal Allocation of Prison Space." In A.J. Swersey and E. Ignall, eds. *Delivery of Urban Services*. TIMS Series in the Management Sciences, **22**, 249-268, Elsevier-North Holland, Amsterdam

Blumstein, A., J.A. Canela-Cacho, and J. Cohen (1993). “Filtered Sampling from Populations with Heterogeneous Event Frequencies.” *Management Science* **39**, 7, 886-899

Chaiken, J. M. and M. R. Chaiken (1982). *Varieties of Criminal Behavior*. Report R-2814-NIJ, The Rand Corporation, Santa Monica, California.

Chaiken, J. M. and J. Rolph (1980). "Selective Incapacitation Strategies Based on Estimated Crime Rates." *Operations Research* **28**, 1259-1274

Clark, John, James Austin, and D. Alan Henry (1997). *Three Strikes and You’re Out: A Review of State Legislation,* in Research in Brief Series, Washington, DC: National Institute of Justice.

Greenwood, P. W. (with A. Abrahamse) (1981). *Selective Incapacitation*. Report R-2815-NIJ, The Rand Corporation, Santa Monica, California

Greenwood, P.W., S.S. Everingham, E. Chen, A.F. Abrahamse, N. Merritt, and J. Chiesa. Forthcoming. *Three Strikes Revisited: An Early Assessment of Implementation and Effects*. RAND, Santa Monica, California

Greenwood, Peter W., C. Peter Rydell, Allan F. Abrahamse, Jonathan P. Caulkins, James Chiesa, Karyn E. Model, and Stephen P. Klein. 1994. *Three Strikes and You're Out: Estimated Benefits and Costs of California's New Mandatory Sentencing Law,* MR-509-RC. RAND, Santa Monica, CA.

Maltz, M. D. (1994). "Operations Research in Studying Crime and Justice: Its History and Accomplishments." In S. M. Pollock, A. Barnett, and M. Rothkopf, eds. *Operations Research and Public Systems*. Elsevier, Amsterdam

Shinnar, Shlomo and Revel Shinnar. 1975. The Effects of the Criminal Justice System on the Control of Crime: A Quantitative Approach. *Law and Society Review*, Vol. 9, No. 4, pp.581-611.

Figure 1: Schematic Model for Calculating Effects of Three Strikes Laws

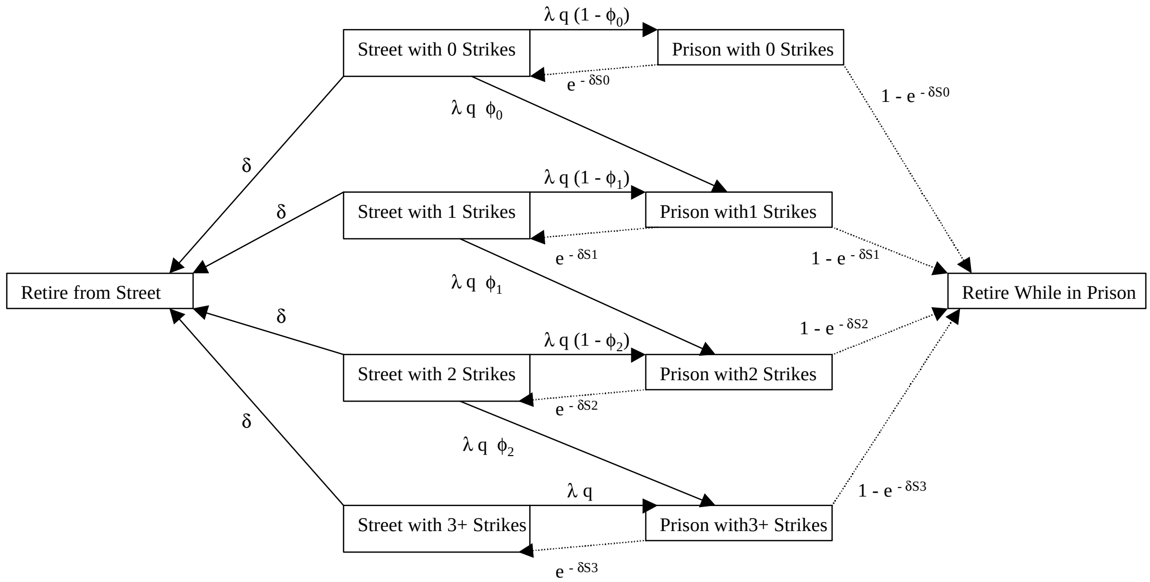

Figure 2: Crimes Averted vs. Increased Cost for Various Policies Concerning What Constitutes a Strike

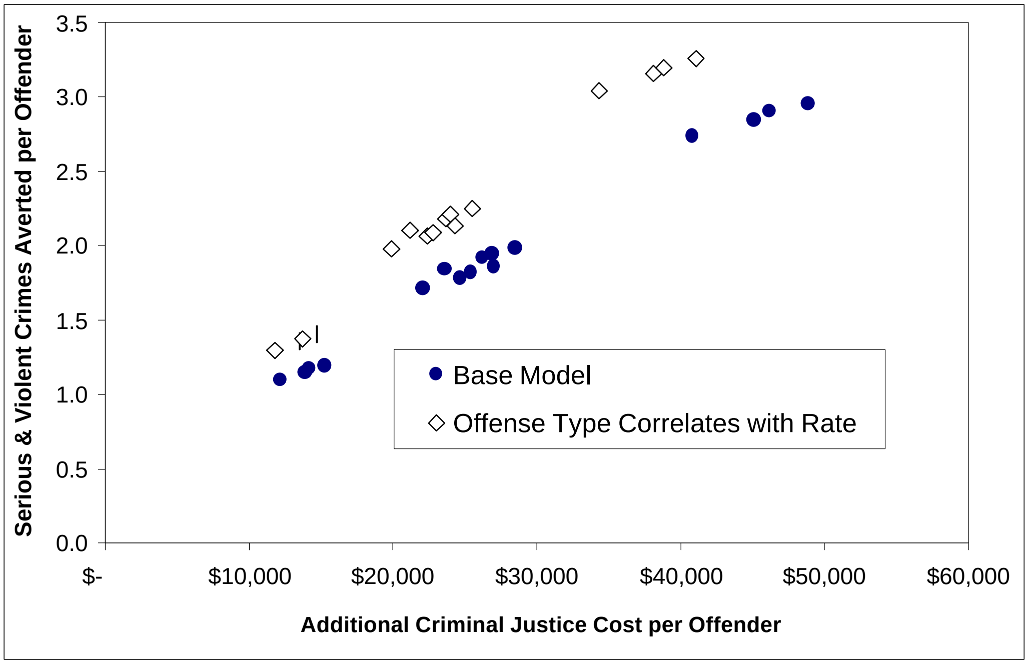

Figure 3: Minimum Cost to Achieve Given Reduction in Crime with Various Strike Definition Schemes