The Rise and Fall of the U.S. Homicide Rate towards the End of the 20th Century
- A System Dynamics Approach –

Kaveh Dianati and Roland Maximilian Happach

European Master in System Dynamics Programme

kaveh.dianati@gmail.com, max.happach@googlemail.com

Abstract

The goal of this paper is to investigate the underlying structure of the socio-economic system leading to the developments of Homicide Rate in the United States during the last two decades of the twentieth century. Specifically, we focus on the effect of the crack cocaine epidemic, and the arms race among street gangs associated with it, on the mentioned developments. We build a System Dynamic model to study the interconnected fabric of important factors. The analysis shows that the arms race triggered by the growth in crack cocaine market, and the reactive policies directed towards having a more effective police force and a higher number of police can explain the overall pattern of the studied behaviour.

Key Words

U.S. Homicide Rate, System Dynamics, Arms Race

Introduction

The plotted graph of the homicide rate, as well as the overall crime rate, in the U.S. between 1960 and 1990 resembles a long uphill hike and a short walk on a plateau. Whereas experts predicted stabilization or even worsening of this situation for the upcoming years (Fox, 1996; Levitt, 2004) the US surprisingly experienced a sharp drop in both crime and homicide rates within the 1990s decade. This development led to a heated discussion about possible reasons among experts, researchers and professionals who claimed to know what happened and why. However, the more contradicting arguments delivered by debaters, the less it can be believed that an ultimate explanation has been found.

Many of the debaters have linked the decline to the improved economic situation (Blumstein & Rosenfeld, 1998; Neumayer, 2003; Freeman, 1996; Donohue J. J., 1998). Levitt (2004), in contrast, believes that economic welfare is important for property crimes but not so much for violent crimes. Ruhm (2000) shows some contradicting results, making it difficult to claim definitive negative correlation between economic welfare and homicide rate. Others correlated the decreasing rates to the availability of weapons especially guns and the laws concerning carrying them (Farley 1980). In particular, Blumstein & Rosenfeld (1998) hold an arms race as a reinforcing cycle responsible for the sharp rise in homicide rates, also arguing that the effectiveness of police confiscating guns contributed to a downturn in violent crimes. On the other hand, Marvell (2001) argues that a ban of weapons leads to more violence, especially against juveniles. He links the absence of guns to more offenses against younger criminals. Furthermore, changing demographics was mentioned as an explanation for the decline of homicides in 1990s (Levitt, 2004; Blumstein & Rosenfeld, 1998). Moreover, Levitt & Donohue (2001) maintained the legalization of abortion in the 1970s to make a significant contribution to the fall in crime. However, Foote & Goetz (2005) claim that this finding is based on calculation mistakes. Furthermore, the number of policemen, neglected by Donohue in 1998 (J. J. Donohue 1998), is a major explanatory reason in his paper together with Levitt (Donohue und Levitt 2001).

As can be seen, the joke about economists that goes "if you ask 10 economists a question, you get 10 different answers" apparently also holds true for criminologists. Certainly, there are factors on which the majority of researchers agree. This includes the idea that developments in the drug-market significantly influenced homicide rates during the late 20th century (Levitt, 2004; Blumstein & Rosenfeld, 1998; Maxfield, 1989).

In previous studies related to this subject, authors rarely looked at these developments from a holistic and dynamic standpoint. Most of these researches are based on time-series and cross-sectional, mostly linear, regressions analysis. The dominant way of thinking here is what Barry Richmond calls "laundry list thinking". Only a few researchers concluded closed-loop causal and possible non-linear relationships from crude data analysis. We believe that a System Dynamics approach is a suitable approach here because we see the developments in the homicide rate not as caused by several straightforward linear 'cause-leads-to-effect' relationships, but as the result of a complex chain of closed-loop feedbacks of several cause-effect relationships each within the socio-economic system. In this paper, we build a System Dynamics model that incorporates feedback loops that we consider as important in reinforcing homicide rates and eventually balancing it out.

But first, we are going to define precisely the Dynamic Problem that we intend to model. Secondly, we present our hypothesis of how this problem developed. In the third section, we analyze our model by comparing its result with historical behaviour and running tests for validating the model. Next, we present a discussion of relevant policies and policy implementation issues. Lastly, we conclude by providing a summary of our research and a discussion of its strengths and limitations.

Dynamic Problem

In this study, we focus on homicide rate which is considered to be the most reliable and accurately measured type of crime (Levitt, 2004; Donohue J. J., 1998). Further, the correlation of homicide to overall crime rate is *0,833* and it can therefore be seen as representative of the overall crime rate. The data is taken from the FBI Unified Crime Report (UCR) and Supplementary Homicide Report (SHR) reports.

The homicide rate in the U.S. increased by more than 30 percent during the second half of the 1980s decade, but then showed an unexpected decline of about 40 percent during the 1990s. Eventually, it stabilized in the last years on a level of 4.8 homicides per 100,000 inhabitants.

Not all homicides are of the same nature. For the purpose of our study, we disaggregate homicides into two categories: family-related and non-family related. Family-related homicides show a slow almost linear decline during the period of our concern (J. J. Donohue 1998). The scale of its change during this period is so small that it does not play an important role in the pattern of rise and fall that is our interest. Therefore, we decided to define our problem as explaining the rise and fall pattern of non-family related homicides during the last 15 years of the twentieth century.

The corresponding development of the homicide rate in the period can be seen in
Figure 1. Our aim is to provide an explanation of the rise within the 1980s and the following decline in the 1990s. We aim to identify the elements of the system and the dynamic relationships between them that led to the turnaround.

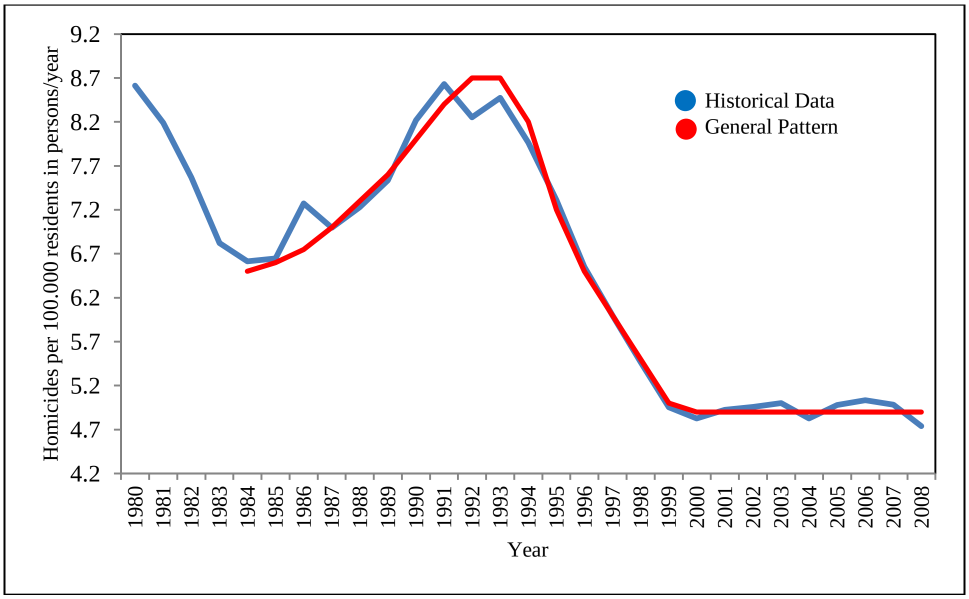


Figure 1. Homicide rate without family related murder per 100,000 residents (Source: FBI SHR Data)

The blue line shown in Figure 1 presents the historical data. Saeed (1998) points out that a reference mode is not just historical data; rather, historical data is only a starting point for building it. A reference mode is a qualitative and abstract concept that represents patterns rather than precise historical data (Saeed 1998). The red line in Figure 1 shows the general pattern of rise and fall in which we are interested. This excludes the minor breaking points and short-term trends in historical data.

Dynamic Hypothesis

For the rise and fall pattern in homicide rates during the late 1980s and 1990s, different explanations have been offered in the criminology literature. One explanation that has been supported extensively by acclaimed authors of the field is the one that relates the behaviour of homicide rates to the developments in the crack market (Donohue, 1998; Blumstein & Rosenfeld, 1998). Quoting from Blumstein & Rosenfeld (1998), "Rates of serious violence, including homicide, went up during the rise phase of the crack epidemic and have been dropping during the decline phase. As the crack epidemic spread in the mid to late 1980s so did the danger around inner city drug markets, driving up the incentive for more kids to arm themselves in an increasingly threatening environment. That environment also became a prime recruiting ground for urban street gangs. Once kids acquired guns to protect themselves from other kids, a classic arms race began, and firearm violence diffused away from the drug markets."

There are at least three important reasons supporting the plausibility of this explanation:

1. The drug-market hypothesis directs attention to the population groups in which the changes in homicide were concentrated: youth, and on African-American youth in particular, who disproportionately participated as sellers in inner-city crack markets.
2. This hypothesis is causally symmetric, meaning that it accounts for both the increase and the decline in violence & homicide rates.
3. The focus on changes in drug markets also helps to account for the variable timing of the peaks and declines in homicide across cities. A large coastal city such as New York, for example, where crack took hold earlier and where it peaked sooner than in other cities, should have experienced a drop in its rate of homicide sooner than in other cities – and it did. Trends in homicide rates in smaller cities are generally lagging behind larger cities.

Also, some of the decline in homicide rates is almost certainly related to the economic expansion during the 1990s. Unemployment rates dropped significantly, and consumer confidence was higher than in nearly three decades. Importantly, economic gains were been shared by racial minorities, teenagers, and high school dropouts, groups at disproportionate risk for serious criminal violence.

Moreover, a number of reactive efforts to fight the drastic rise in violence during the late 1980s certainly contributed to the subsequent improvement during the 1990s. Notable among the reactive forces are police efforts to remove guns from kids. To the extent that the carrying is reduced thereby, it in turn reduces the concern over self- protection, and thereby diminishes the incentive for others to carry their own guns. Thus, the contagious escalation characteristic of the rise period can display a similar contagion process of disarmament during the decline period.

Thus, our hypothesis for the studied problem is the following: The rise of the crack cocaine market in the mid 1980s immediately led to an increase in violent incidents in susceptible communities. This triggered an increased rate of acquisition of guns by criminals, involved in any kind of crime, to protect themselves in the increasingly dangerous environment. More and more immature street kids armed with firearms meant dangerous toys landing in the hands of the wrong people. This can also be thought of as an example of a classic arms race. This assumption is also consistent with other sources in the literature. Decker (1996) argues that gang members perceive a threat from rival gangs and get armed in order to protect their corners. Strodtbeck and Short Jr. (1964) state that carrying a gun is a method to gain respect in the gang especially among newcomers. We combine both theories arguing that the boom in the drug market led to more guns and more criminals. This resulted in an escalation of armament which led to the peak in homicides, not only because of drug-related homicides, but because with more guns carried by criminals the violence diffused away from the drug market and caused more homicides in any kind of potentially violent situation. Eventually, reactive efforts such as raising investment in hiring new police force and adopting new strategies against possessing and carrying illegal guns, and also the independent effect of a thriving economy, drove down the homicide rate.

Causal Loop Diagram

Based on all the insights obtained through a review of the subject literature, we built a causal feed-back loop model, following the System Dynamics approach. First, let us have a look at the basic feedback structure that generated the developments in homicide rate that we intend to explain.

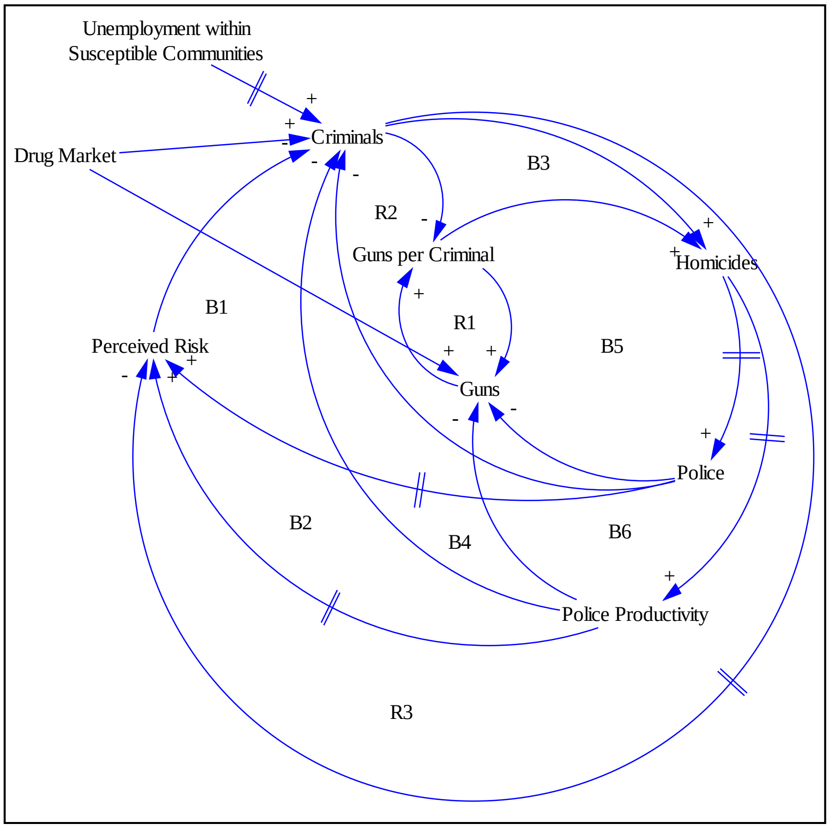


Figure 2. Causal Loop Diagram

Our variable of interest is 'Homicides', located at the right hand side of Figure 2.

The number of homicides committed is affected by the number of 'Criminals', and the amount of 'Guns per Criminal'. Criminals commit homicides in different kinds of violent situations, such as robbery, street fights, or gang disputes. Whether these situations lead to homicide or not depends on the average number of guns carried by criminals, which is shown in the variable 'Guns'. Therefore, the variable 'Guns per Criminal' represents a measure of threat. The bigger this number, the more criminals possess a gun leading to more threat for others not carrying a gun.

In our model, the decision of susceptible persons on whether or not to lead a life of crime depends on an evaluation of the 'Perceived Risk' against the relative rewards included. The relative reward perceived is increased by new profit opportunities from the drug market and decreased by legitimate income earning opportunities provided, which is affected by 'Unemployment within Susceptible Communities'. Both perceptions – reward and risk – are changing slowly, indicated by a delay.

The major reinforcing feedback loop that is driving up homicides during the second half of the 1980s decade is loop *R1*: As more 'Criminals' acquire guns through illegal gun distribution channels that are aggressively profiting from the demand generated by the expanding crack market, more peers are going to feel threatened and buy guns for themselves. The larger base of gun possession is going to stimulate more gun acquisition the next time round. This loop refers to the arms race. Moreover, there are two reinforcing effects *R2*&*R3* resulting from risk perception. Firstly, as the number of criminals increases, ceteris paribus, it will lower the 'Gun per Criminal' ratio and, consequently, reduce homicides. Further, less police will be hired which, in turn, leads to lower 'Perceived Risk' and more 'Criminals'. Secondly, more 'Criminals' in the neighbourhood leads to lower perception of risk in becoming a criminal. This effect is shown in *R3*. Both latter reinforcing loops are delayed because of the time needed to change perceptions and hiring additional police and play a minor role.

There are several major balancing feedback loops that have counteracted violence and contributed to the downturn of homicide rates are. All of these loops operate with delay. Higher 'Homicides per Year' lead to higher investment in police force effectiveness, called 'Police Productivity' and a larger number of 'Police'. 'Police Productivity' refers on the one hand to confiscation, i.e. finding illegal guns, which is not necessarily linked to arrests. On the other hand, the productivity in arresting people can be increased by more aggressiveness and new strategies. Thus, the more numerous and more effective cops are going to drive violence down through confiscating illegal guns (*B5*&*B6*), and through more Arrests (*B3&B4*). More effective Police Force drives up the perceived risk in becoming a criminal and thus negatively affects the number of criminals (*B1*&*B2*). We distinguish between the number of police and their productivity because they represent different but important leverage points for policy.

There are two major exogenous effects that are significant in this system. 'Unemployment within Susceptible Communities' which directly affects criminalization with a certain delay, and developments in the Drug Market that is related with high potential profit which leads to an increase in the number of criminals and guns carried by those. This shock is immediate because of the high potential profit related to crack cocaine.

Model Analysis

Comparison with the Reference Mode

Assuming that the drug market went through a period of boom & bust and using a pulse function starting at 1984 and ending in 1991 to model it, the following figure shows the comparison of the behaviour of our model versus historical data. Clearly, the underlying structure replicates quite well the real world pattern.

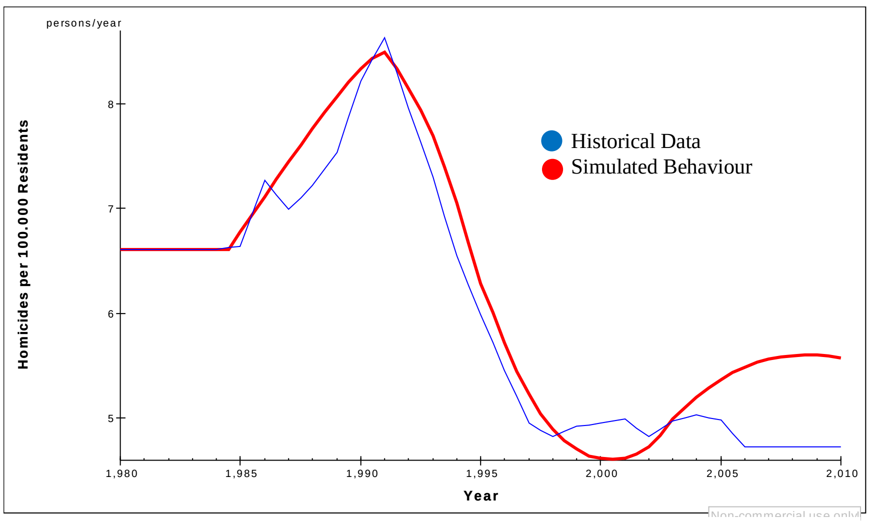


Figure 3. Simulated Behaviour vs. Reference Mode

As can be seen in Figure 3, the rise and fall pattern of the reference mode is evident in both graphs. However, the two graphs are not exactly similar in regard to differences in rising points, peaks and slopes. The simulation shows a rise a little earlier in time, a slightly lower peak and a slower rising slope in comparison with the reference mode. The simulated behaviour has some damped oscillations in the end, which has not been exactly the case in the real world. Thus, our model seems to show a rise in the homicide rate in the future, over which some experts have expressed concern (J. J. Donohue 1998).

Policy Design and Implementation

This paper studies a historical problem rather than a currently existing one. Some policies regarding the problem of extremely high homicide rate in the beginning of the 20th century have already been implemented and some favourable results have already resulted. Thus, the most important policy levers are already built-in parts of our model, and constitute our major balancing feedback loops which are already discussed. Therefore, in this part we intend to summarize which policies have been used in order to achieve the decline. We then set off on evaluating them. In the coming discussion, we also want to point out what could have been done in a better way in order to have a sustainable stabilization, and also, where we see risks for the future.

There were many policies involving the police force, regarding both the number of police hired and also policing strategies. In the historical data, we observe a rise in the number of police beginning in 1984 and peaking in 2000 at 25% higher. Since then, the number of police per capita has been falling slowly and steadily, along with the falling crime rate but with a delay of around 7 years. This policy helps reduce crime both directly through arresting more of the criminals, and indirectly, and perhaps more importantly, through increasing the perceived risk in becoming a criminal, and thus, limiting the inflow to the stock of criminals. The policy of increased hiring is embedded in our model and therefore, the model successfully reproduces the pattern of rapid rise and slow decline in the number of police.

Another major police-related policy is adjustments in police strategies (Levitt, Understanding Why Crime Fell in the 1990s: Four Factors that Explain the Decline and Six that Do Not 2004). One important strategy conducted was increased attempts at confiscation of illegal firearms, such as stop-and-frisk initiatives (Montgomery, 1996; Dilulio, 1996), “voluntary” searches of homes suspected of containing weapons or promised bounties for reports leading to confiscation of illegal guns (Blumstein & Cork, 1996). Further examples of gun related policies are the Violent Crime Control and Law Enforcement Act 1994, which among others regulates the sale of handguns to juveniles (Violent Crime Control & Law Enforcement Act 1994 1994). Blumstein & Rosenfeld explain the dynamic effect of this policy most eloquently: "The theory behind the confiscation strategies lies not only in the benefits of the confiscation itself, but in the broader deterrent threat that the risk of confiscation has on the carrying of the weapons or on the brandishing of a gun. To the extent that the carrying is reduced thereby, it in turn reduces the concern over self- protection, and thereby diminishes the incentive for others to carry their own guns. Thus, the contagious escalation characteristic of the rise period can display a similar contagion process of disarmament during the decline period." Further proof of changes in the confiscation strategies is the 1990 launched legal ban of weapons from schools in the Gun-Free Schools Zone Act (The Crime Control Act of 1990 1990) and the appearance of weapon tracing statistics in the internet since early 2000s. We conclude that a special gun tracing department or task force was put into place. Confiscation is built in as an important variable in our model, which contributed a lot to the regeneration of the decline period of homicides. Without this policy structure the model was not at all able to reproduce the rapid decline in homicides.

Furthermore, a policy implementation issue that must be taken into account is the delay involved between investing in police force and observing results. These delays were included in our model to correctly reproduce the reference mode of behaviour. At the moment, since homicide rate is relatively low, police force is well likely to become the victim of budget shortages. Decision-makers must not reason that since budget cuts did not show an immediate effect on crime, it is a wise decision to cut police budgets. Important delays inherent in the effect of the strength of police force and homicide rate, or crime rate in general, must be acknowledged. In fact, our model shows an eventual rising of homicides up again after 2000, which is to some extent in harmony with actual historical data. This is because of the fact that in our model we presumed a 'Normal Homicides' as a constant parameter, based on which investment decisions on police is made. Since this perception of what is 'normal' does not change during our simulation period, homicide rate tends to be pulled slightly towards it. Therefore, in the real world, if the goal is to bring homicide rate as low as possible, the 'normal' value for this, and along with that the 'normal' level of investment, should be constantly adjusted.

In conclusion, according to our modelling and analysis, two major rates were the vicious drivers that made homicide go up in the late 1980s: 'Criminalization' & 'Acquisition' (of guns). Whatever policy that could pull down these rates would have helped reduce the peak in homicides. Regarding Criminalization, an important long-term policy lever is education. Educating members of crime-susceptible neighbourhoods expands their legitimate money-earning opportunities and reduces their perceived reward in becoming a criminal, while of course educating them about the high risks. Along with efforts pointed towards education that give delayed results, short-term policies of increasing legitimate income available for low-skill jobs can also be used. This policy should be used with care, not so that the system becomes too much reliant on a tranquilizer that kills the pain but does not cure the disease. Blumstein & Rosenfeld (1998) provide a useful discussion on this. As for gun Acquisition, the police should be wary of the likely arms race that comes along with booms in the drug-market. This means that initiatives should be specifically directed towards stopping gun dealers that see drug booms as perfect opportunities, from distributing guns in the society. Also, a more preventive strategy is to launch campaigns against drug use. These campaigns should be launched nationwide, not only focussing on certain age groups or social classes. Such a preventive campaign is right now ongoing against Methamphetamine. Posters, discussions with school kids, and TV shows are examples of the media that is being effectively used to treat the topic. That is a first step into the right direction, even though we cannot be certain about whether or not the message reaches all social groups.

Conclusion

In this paper we studied the underlying structure of the socio-economic system leading to the developments of Homicide Rate in the United States during the last two decades of the twentieth century. Homicide Rate started to rise rapidly around 1984 from an initial level of around 6.6

homicides per 100,000 residents per year, peaked in the early 1990s at about 8.6 homicides per 100,000 residents per year, and then declined by more than 40 percent to reach a new, somewhat stable, level of around 4.8 homicides per 100,000 thousand residents per year.

There is no shortage of explanations for this pattern of behaviour in homicide rate. Having studied some of the most influential articles in the subject literature, we came up with a dynamics story that, in our opinion, explains well the structure and dynamics leading to this rise and fall.

The rise of the crack cocaine market in the mid 1980s immediately led to an increase in of criminals and guns leading to more violent incidents in susceptible communities. However, this effect of increased level of violence due to the drug business alone is far from enough to explain the drastic rise in homicides. Nonetheless, this effect was strong enough to stimulate an increased rate of acquisition of guns by criminals, involved in any kind of crime, to protect themselves in the increasingly dangerous environment. This can be thought of as an example of a classic arms race. An increased level of guns carried by street criminals with an immaturely low threshold of readiness to use them, in any kind of potentially violent situation and not just drug-related fights, led to the peak in homicides. Eventually, reactive efforts such as raising investment in hiring new police force and adopting new strategies against possessing and carrying illegal guns drove down the homicide rate. Furthermore, the growing economy of the 1990s contributed to this trend by providing more legal money earning opportunities for ghetto kids and decreasing the rate at which they enter a life of crime. The System Dynamics model that was created in this research validates this hypothesis and makes it easy to visualize and to communicate to policymakers as a guideline for future decisions. The model, or an improved version of it with a specific purpose, can also be used to test different potential policies.

In previous studies related to this subject, authors rarely looked at these developments from a holistic and dynamic standpoint. In his review paper, Levitt (2004) collects 10 of the most cited reasons regarding the rapid decline in the 1990s, ranging from legalization of abortion to laws against carrying concealed weapons, and to increased number of police. The reviewed hypotheses have appeared either in scientific journals, mostly applying econometric and regression methods to test their theories, or in the media, which apply common sense as their primary source of evaluation. These hypotheses predominantly involve reasoning based on correlation, coincidence, simultaneity, and spatial or temporal proximity. The predominant line of reasoning in the articles that Levitt reviewed has been an open-loop way of thinking, assuming a single cause with a straightforward 'cause-leads-to-effect' way of thinking for the studied developments. The System Dynamicist's point of view, on the hand, is that "the world is dynamic, evolving, and interconnected" and "Effect is rarely proportional to cause" (Sterman, 2000: 22).

Indeed, some of the articles in the subject literature, the ones that helped us come up with our dynamic hypothesis, did look at the problem in a complex and dynamic manner. The paper that was most influential for us was Blumstein & Rosenfeld's "Explaining Recent Trends in U.S. Homicide Rates" (1998). In their paper, Blumstein & Rosenfeld supported their story by providing several time-series data of the major variables and reasoning based on them. As such, their explanations were very well-founded if evaluated by common sense, but still lacked

scientific rigour. Translating the hypothesis inspired by this article into an system dynamics model, we believe, provided the missing rigour.
Nevertheless, our study is prone to be criticized for many different reasons. Some of the major limitations of our research are:

- Occasional arbitrary choice of values for model parameters. Of course we ran several sensitivity tests to test the sensitivity of the ability of the model to regenerate the reference mode to different parameters. The model showed quite sensitive to some parameters. A few of our assumptions for these sensitive parameters lack the necessary support in real-world data. These include 'Arms Race Constant', initial number of 'Criminals' in a society of 100,000 residents, and the initial number of 'Guns' carried by those.
- Also, a decisive element of our model is the 'Drug Market' variable which currently is a pulse with a constant value of one, starting in 1984 and ending in 1991, representing an assumption that the volume crack market suddenly grew to a certain level, stayed constant for 7 years, and then suddenly dropped. This is a questionable assumption. We can reason that changing this behaviour within reasonable ranges does not change the overall pattern of behaviour, but still we need to collect more data about the emerging and fading of the crack market. However, the research shows the linkage between the sudden appearance and unfavourable social outcomes. Crack cocaine quickly eclipsed other drug profits. That came along with violence, which later declined in the mid-90s as the market matured, prices fell sharply and property rights were established (Fryer Jr. et al, 2005).
- The way that we modelled the reward side of becoming a criminal, which is changed, directly and with a simple formulation, through the payoff of the drug market against the payoff of legitimate available job is simplistic. Moreover, Levitt and Venkatesh (2000) find that economic factors are unlikely to sufficiently describe involvement in criminal activity. There is considerable room for improvement in the part of the model that captures people's decision on whether to become a criminal or not.
- An important assumption of our model is the aggregation of all criminals in one stock. This presumption can easily be the target of criticism since demographic groups of criminals or potential criminals behave in different ways. For a more detailed explanation of the issue at hand, we recommend future researchers to divide this single population stock into multiple age & demographic groups. Blumstein & Rosenfeld (1998) provide a very useful comparison of the behaviour of these different demographic groups regarding our subject.
- One important variable in our model is Normal Homicides, which is constant at 6.61 homicides per year, the starting point of historical data. We then adjust this 'Normal' value to changes in the endogenous variables than determine Homicides. This 'Normal' value is also the reference value for adjusting investments in the Police force. The assumption that the value considered as 'Normal' by policymakers is constant is very simplistic. An important improvement to make our model more realistic is to adjust this perception over time, possibly using a TREND function.
- In formulating Perceived Risk, we assume that potential criminals have a rough idea of the ratio of Arrests/Criminals, meaning that they adjust their perception based on an estimation of what percentage of criminals are eventually arrested. This assumption may or may not be true and needs validation/improvement since some neighbourhoods tend to have a higher percentage of criminal residents than other.

References

Blumstein, Alfred, and Daniel Cork. "Linking Gun Availability to Youth Gun Violence"." *Law & Contemporary Problems Vol. 59 No.1 Kids, Guns, and Public policy*, 1996: 5-24.
Blumstein, Alfred, and Richard Rosenfeld. "Explaining Recent Trends in U.S. Homicide Rates." *The Journal of Criminal Law and Criminology Vol. 88 No. 4 Symposium: Why Is Crime Decreasing?*, 1998: 1175-1216.
Decker, Scott H. "Collective and Normative Features on Gang Violence." *Justice Quarterly Vol.13 No. 2*, 1996: 243-264.
Donohue, John J. "Understanding the Time Path of Crime." *The Journal of Criminal Law and Criminology Vol. 88 No. 4 Symposium:Why Is Crime Decreasing?*, 1998: 1423-1452.
Donohue, John, and Steven Levitt. "The Impact of Legalized Abortion on Crime." *The Quarterly Journal of Economics Vol. 116 No. 2*, 2001: 379-420.
Farley, Reynolds. "Homicide Trends in the United States." *Demography Vol. 17 No. 2*, May 1980: 177-188.
Foote, Christopher, and Christopher Goetz. "Testing Economic Hypotheses with State-Level Data: A comment on Donohue and Levitt (2001)." *Federal Reserve Bank of Boston working paper 05-15*, 2005.
Fox, James. "Trends in Juvenile Violence: A Report to the United States Attorney General on Current and Future Rates of Juvenile Offending."." 1996.
Freeman, Richard. "Why Do So Many Young American Men Commit Crimes and What Might We Do About It?" *The Journal of Economic Perspectives Vol. 10 No. 1*, 1996: 25-42.
Fryer Jr., Roland G., Paul S. Heaton, Steven D. Levitt, and Kevin M. Murphy. "Measuring the Impact of Crack Cocaine." *National Bureau of Economic Research Paper Series No. 11318*, 2005.
Jr., John J. Dilulio. "How to Deal with the Youth Crime Wave." *The Weekly Standard*, September 1996: 30.
Levitt, Steven D. "Understanding Why Crime Fell in the 1990s: Four Factors that Explain the Decline and Six that Do Not." *The Journal of Economic Perspectives Vol. 18 No.1*, 2004: 163-190.
Levitt, Steven D., and Sudhir Alladi Venkatesh. "An Economic Analysis of a Drug-Selling Gang's Finances." *The Quarterly Journal of Economics Vol. 115 No. 3*, 2000: 755-789.
Marvell, Thomas. "The Impact of Banning Juvenile Gun Possession." *Journal of Law and Economics Vol. 44 No. 2 Part 2 Guns, Crime, and Safety: A Conference Sponsored by the American Enterprise Institute and the Center for Law,Economics, and Public Policy at Yale Law School*, 2001: 691-713.
Maxfield, Micheal. "Circumstances in Supplementary Homicide Reports: Variety and Validity." *Criminology Vol. 27 No. 4*, 1989: 671-695.
Montgomery, Lori. "Crime Falls in Big Cities as Murders Drop by 8%." *Pittsburgh Post-Gazette*, May 1996.
Neumayer, Eric. "Good Policy Can lower Violent Crime: Evidence from a Cross-National Panel of Homicide Rates, 1980-1997." *Journal of Peace Research Vol. 40 No. 6*, 2003: 619-640.
Ruhm, Christopher. "Are Recessions Good For Your Health?" *Quarterly Journal of Economics Vol. 115*, 2000: 617-650.

Saeed, Khalid. “Defining a problem or constructing a reference mode.” Worcester: Worcester Polytechnic Institute, 1998.
Sterman, John D. *Business Dynamics. Systems Thinking and Modeling for a Complex World.* United States: McGraw-Hill, 2000.
Strodtbeck, Fred L., and James F. Short Jr. “An Explanation of Gang Action.” *Social Problems Vol. 12*, 1964: 127-140.
The Crime Control Act of 1990. Pub.L. 101-647, 104 Stat. 4789 (1990).
Violent Crime Control & Law Enforcement Act 1994. Pub. L. No. 103-322 108 Stat. 1796 (1994).

Appendix A: Stock and Flow Diagram

The structure of our model includes some essential building blocks which are of paramount importance to its dynamic behaviour. These blocks are what we are going to elaborate on in this section.

'Criminals' and 'Guns' carried by those criminals are the two decisive stocks in the model, shown in Figure 4. These stocks bring about inertia and potential policy resistance to the real-world system. Also, the major loop, *R*, shown in the causal loop diagram in Figure 2 including the stock of 'Guns' and the 'Gun per Criminal' ratio, ,is a self-reinforcing vicious entity.

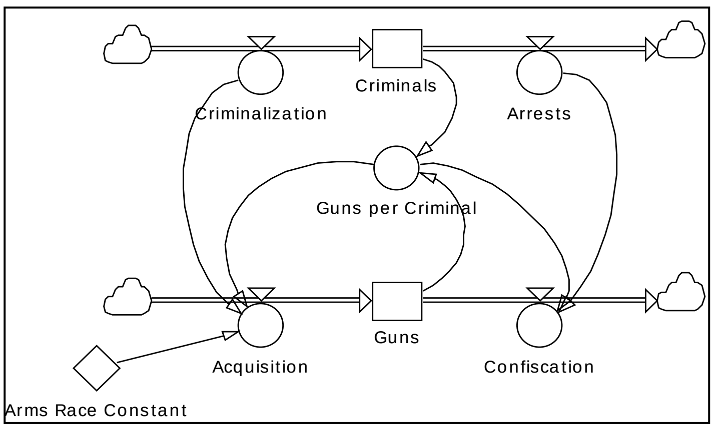


Figure 4. The two stocks of 'Criminals' and 'Guns' and their interaction

Another structural characteristic of the system is the delay involved in the effect of 'Homicide per Year' on 'Police' over 'Hiring' seen in Figure 5 which represents the time it takes for decision-makers to perceive the criticality of the situation, to invest more in the recruiting and training of more police to counter the growing violence in the streets. Further, the effect of 'Homicides per Year' on the productivity of police force is shown. Again, the time perceiving criticality is shown. These delays permits violence to go unchecked for quite some time.

A last important characteristic in the model is the nature of becoming criminal, called 'Criminalization'. This inflow is influenced by the risk perception, which is the ratio of 'Arrests' to 'Criminals' and the reward perception, which is influenced by the exogenous variable 'Legal Income Opportunities'. As already mentioned in the description of the causal loop diagram, both – risk and reward – is perceived with a delay. The basic structure can be seen in Figure 6. For a full list of equations refer to Appendix B.

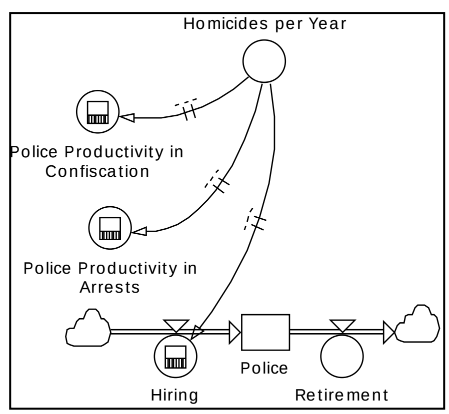


Figure 5. Delayed Reactive Forces Against Homicides

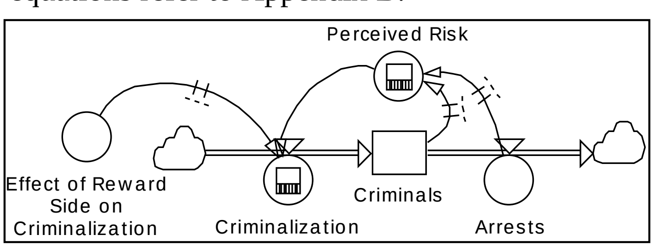


Figure 6. The Inflow of Criminals is Influenced by Delayed Perceptions

Appendix B: list of Equations and Documentation

*All Graph functions are shown in the separate section at the end of this Appendix.
* Our model assumes a total population of 100,000 residents. All variable values should be regarded with this in mind.

Constants

Name	Unit	Initial Value
Arms Race Constant	*gun/year*	5.5
Effect of Drug Market on Criminalization	*criminal/year*	10
Minimum Wage	*dollar/year*	15,000
Normal Acquisition	*gun/year*	30
Normal Criminalization	*criminal/year*	100
Normal Guns per Criminal	*gun/criminal*	0.3
Normal Hiring	*cop/year*	10
Normal Homicides	*person/year*	6.61
Normal Legal Income Opportunities	*dollar/year*	7,500
Normal Police Productivity in Arrests	*criminal/(year*cop)*	1/3
Normal Police Productivity in Confiscation	*gun/(year*cop)*	0.1
Normal Violent Criminal Incidents	*incident/year*	1,000
TimeToRetire	*year*	30

Stocks

Name	Equation	Unit	Initial Value
Criminals	Criminals(t) = Criminals($t-1$) + Δt * (Criminalization – Arrests)	*criminal = criminal + years * (criminals/year – criminals/ year)*	1,000
Guns	Guns (t) = Guns ($t-1$) + Δt * (Acquisition – Confiscation)	*gun = gun + years * (guns/year – guns/year)*	300
Police	Police (t) = Police ($t-1$) + Δt * (Hiring-Retirement)	*cop = cop + years * (cops/year – cops/year)*	300

Flows

Name	Equation	Unit	Initial Value
Acquisition	'Normal Acquisition' + 'Drug Market' * (1+'Guns per criminal'/'Normal Guns per Criminal') * 'Arms Race Constant'	*gun/year = gun/year + 'unitless' * (1 + gun/criminal / gun/criminal) * gun/year*	60

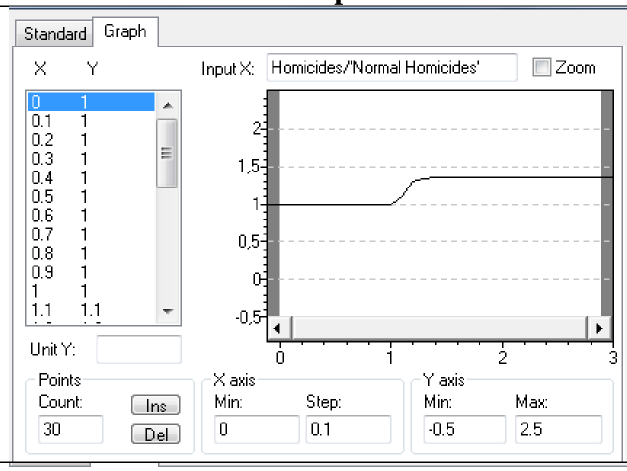
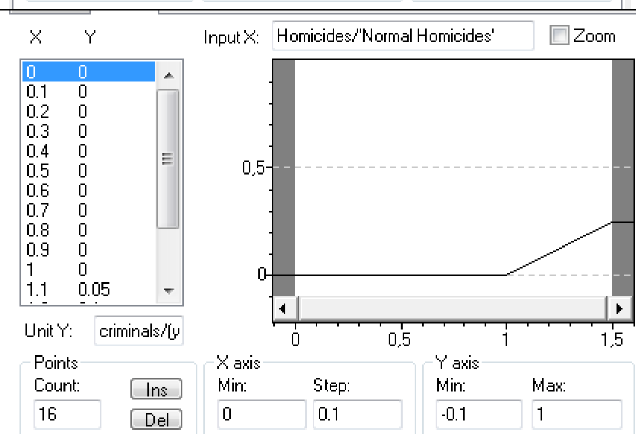
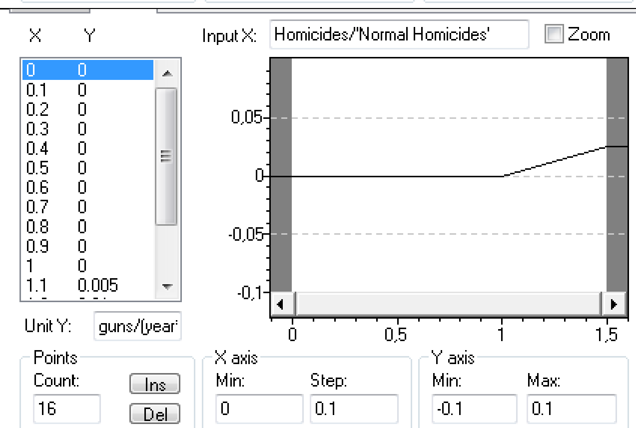
	+ Criminalziation * 'Guns per criminal'	+ *criminal/year * gun/criminal*	
Arrests	Police*'Police Productivity in Arrests'*GRAPH(Criminals,0<<criminals>>,100<<criminals>>)	*criminal/year = cop * criminal/(year*cop) * ‘unitless’*	100
Confiscation	GRAPH(Guns,0<<guns>>,20<<guns>>) * Police * 'Police Productivity in Confiscation' + Arrests * 'Guns per criminal'	*gun/year = ‘unitless’ * cop * guns/(year*cop) + criminal/year * gun/criminal*	60
Criminalziation	('Normal Criminalization' + 'Drug Market' * 'Effect of Drug Market on Criminalization') *GRAPH ('Perceived Risk',0<<1/year>>,0.02<<1/year>>) * DELAYINF('Effect of Reward Side on Criminalization',10<<years>>,3,1)	*criminal/year = (criminal/year + ‘unitless’ * criminal/year) * ‘unitless’ * ‘unitless’*	100
Hiring	'Normal Hiring' * DELAYINF('Effect of Homicides on Hiring',1<<years>>,3,1)	*cop/year = cop/year * ‘unitless’*	10
Retirement	Police/TimeToRetire	*cop/year = cop / year*	10

Auxiliaries

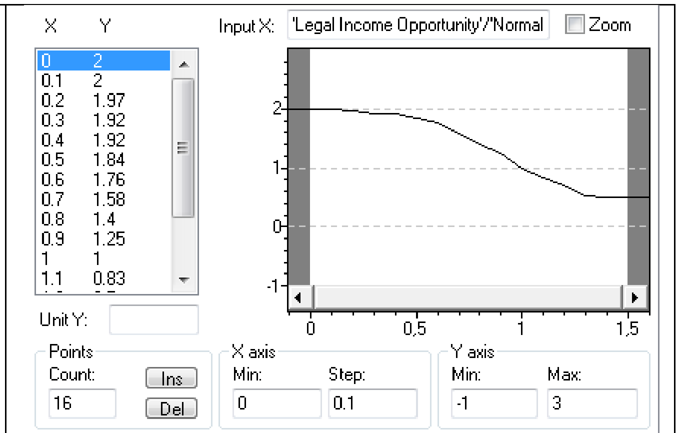
Name	**Equation**	**Unit**	**Initial Value**
Drug Market	STEP(1,1984.5<<@year>>) - STEP(1,1991<<@year>>)	*‘unitless’*	0
Effect of Homicides on Hiring	GRAPH(Homicides / 'Normal Homicides',0,0.1)	*‘unitless’* = GRAPH*(person/year / person/year)*	1
Effect of Homicides on Police Productivity in Arrests	GRAPH(Homicides / 'Normal Homicides',0,0.1, <<criminals/(year*cop)>>)	*criminal/(year*cop)* = GRAPH*(person/year / person/year)*	0
Effect of Homicides on Police Productivity in Confiscation	GRAPH(Homicides / 'Normal Homicides' ,0,0.1,<<guns/(year*cop)>>)	*gun/(year*cop)* = GRAPH *(person/year / person/year)*	0
Effect of Reward	GRAPH('Legal Income	‘unitless’ =	1

Side on Criminalization	Opportunity' / 'Normal Legal Income Opportunities',0,0.1)	GRAPH_(dollar/year / dollar/year)_	
Guns per Criminal	Guns/Criminals	_gun/criminal = gun / criminal_	0.3
historical Homicide Rate without family homicides	GRAPH(TIME,1984<<@year>>,1 <<year>>,<<persons/year>>)	_person/year_ = GRAPH	6.61
historical Police Force Development	GRAPHCURVE(TIME, STARTTIME,1<<years>>, <<cops>>)	_cop_ = GRAPHCURVE	207.9
Homicides	'Normal Homicides' * ('Guns per criminal' / 'Normal Guns per Criminal') * ('Violent Criminal Incidents' / 'Normal Violent Criminal Incidents')	_person/year = person/year * (gun/criminal / gun/criminal) * (incident/year / incident/year)_	6.61
Legal Income Opportunity	1-'Unemployment within Susceptible Communities') *'Minimum Wage'	_dollar/year = (1 – ‘unitless’) * dollar/year_	7,500
Perceived Risk	DELAYINF(Arrests/Criminals, 0.5<<years>>,6,0.1<<1/year>>)	_1/year = criminal/year / criminal_	0.1
Police Productivity in Arrests	'Normal Police Productivity in Arrests' + DELAYINF('Effect of Homicides on Police Productivity in Arrests', 1<<years>>,10,0 <<criminals/(year*cop)>>)	_criminal/(year*cop) = criminal/(year*cop) + criminal/(year*cop)_	1/3
Police Productivity in Confiscation	'Normal Police Productivity in Confiscation'+ DELAYINF ('Effect of Homicides on Police Productivity in Confiscation', 1<<years>>,10,0 <<guns/(year*cop)>>)	_gun/(year*cop) = gun/(year*cop) + gun/(year*cop)_	0.1
Unemployment within Susceptible Communities	GRAPH(TIME,1995 <<@year>>,1<<year>>)	_‘unitless’_= 0.5 - GRAPH	0.5
Violent Criminal Incidents	'Normal Violent Criminal Incidents'* GRAPH(Criminals, 0<<criminals>>, 100<<criminals>>)*GRAPH (Police,200<<cops>>,25<<cops>>)	_incident/year = incident/year * GRAPH(criminals) * GRAPH(cop)_	1,000

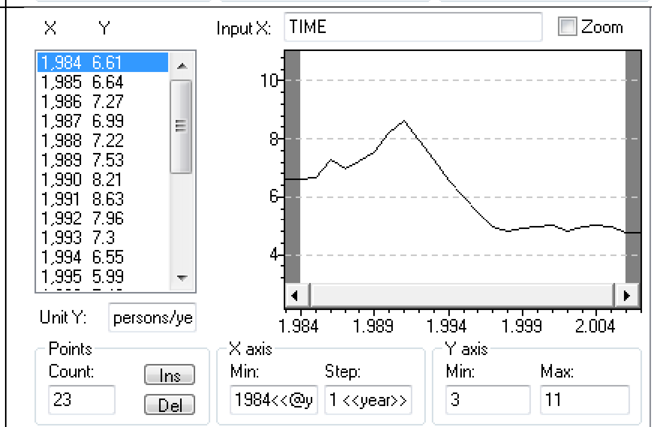
Graph Functions

<table>
<tr><th>Variable Name</th><th>Graph</th></tr>
<tr><td>Effect of Homicides on Hiring</td><td>
</td></tr>
<tr><td>Effect of Homicides on Police Productivity in Arrests</td><td>
</td></tr>
<tr><td>Effect of Homicides on Police Productivity in Confiscation</td><td>
</td></tr>
</table>

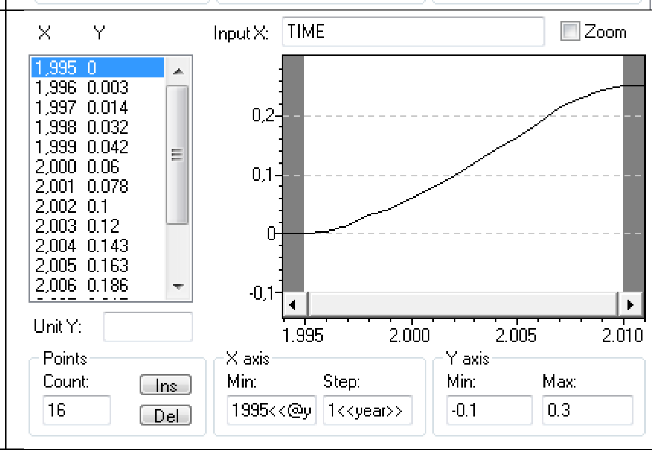
Effect of Reward Side on Criminalization

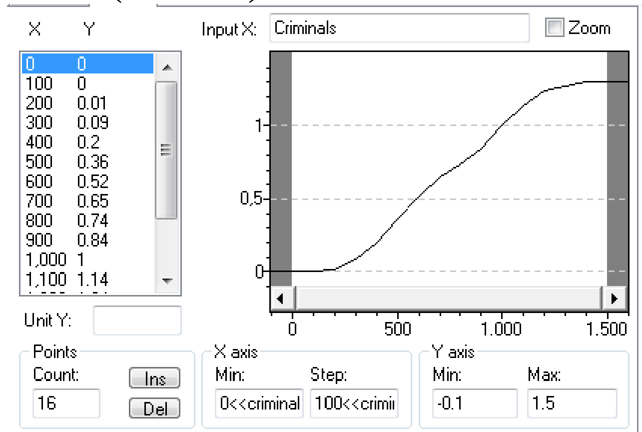


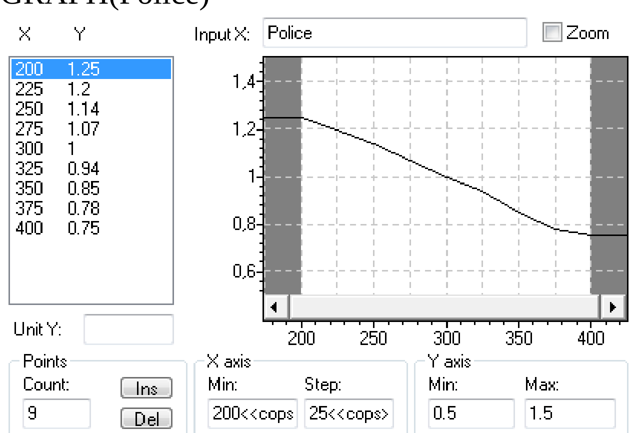
historical Homicide Rate without family homicides



Unemployment within Susceptible Communities



<table>
<tr>
<td>Violent Criminal Incidents</td>
<td>GRAPH(Criminals)


GRAPH(Police)


</td>
</tr>
</table>

Appendix C: Detailed Model Analysis

Structure Behaviour Tests

Going back to the Dynamic Hypothesis section, we remember that we hypothesized that the major dynamics in our model comes from an ‘arms race’ in criminals. To test this hypothesis, we eliminate this dynamic by setting ‘Arms Race Constant’ to zero and we simulate the model. Without an arms race there would still be a slight increase in homicides along with the outbreak of the crack cocaine market. However, the peak would be much lower if it was not for the climate of increasing threat of violence in the streets. Of course, in that case homicide rate would not go as low as they actually did because there would not be an equally high feeling of urgency to invest in having more cops. That is why we would also have a higher trough in homicide rate at the end of the decade if it was not for the arms race. With this test, we can be confident that the main pattern of behaviour in the model is being produced due to endogenous dynamic, and not because of the exogenous inputs fed into it.

Cutting the feedback from ‘Homicides per Year’ to all reactive policies (Police and Productivity, *B3-B6*), the homicide rate would stay high. Adding the effect of ‘Homicides per Year’, i.e. cutting loops *B4 & B6*, shows that ‘Hiring’ has a big impact on the overall pattern. The other loops show less important influence on the simulated pattern. For further details and proof, please see the end of this Appendix.

Extreme condition tests

a) Playing with Cops

One of our assumptions in the model is an initial number police. To test the plausibility of our model structure, we conducted an extreme condition test on this particular value. Firstly, we wanted to see what behaviour the model would generate in an initial absence. Secondly, we run the model with an initial excessively high police force.

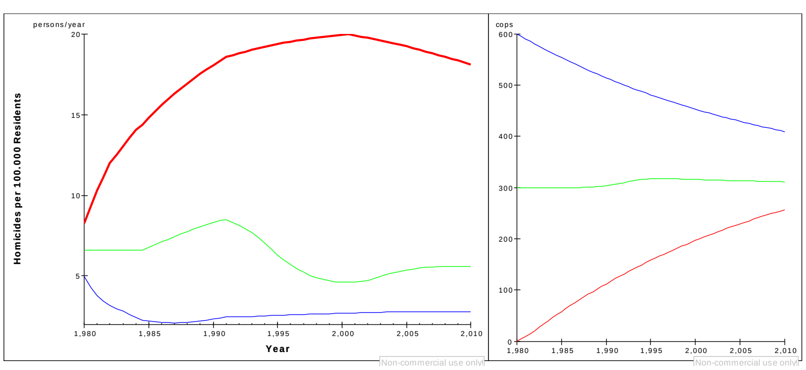


Figure 7. Playing with Cops: Left Side: Homicide Rate | Right Side: Police Stock - Legend: green - base run (300 cops), red - initial absence of police (0 cops), blue - high number of police (600 cops)

As can be expected a fast increasing homicide rate results from the absence of cops. However, eventually the homicide rate should be heading down because the as homicides rise more policeman will be recruited, which leads to more arrests. Also, if there are too many policemen, the homicide rate has to decline. Towards the end of the time horizon the homicide rate starts to rise again. This can be due to the fact that the presence of too many policemen leads to a low homicide rate which negatively affects the hiring of police force. That in turn pushes the homicides to a higher level. The simulation generates behaviour according to our expectations, shown in Figure 7.

b) Playing with Guns

Another assumption in the model is an initial number of 'Guns' by 'Criminals', equal to 300 guns, implying that to begin with, thirty percent of the 'Criminals' possesses guns. Our second extreme condition test takes this variable to two opposite ends of extremity.

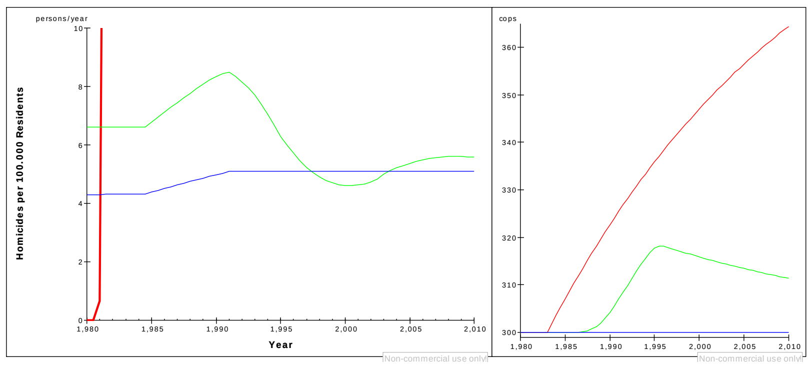


Figure 8. Playing with Outlaws with 'Gun' adjustment: Left Side: Homicides per Year | Right Side: Police Stock - Legend: green - base run (1000 criminals), red - absence of criminals (1 criminal), blue – a lot of criminals (2000 criminals)

Firstly, doubling this number, meaning that initially more than the half of the criminals is in possession of a gun, leads to a very high initial homicide rate. Nevertheless, this high level of homicide leads to hiring more and more cops, which results in an eventual lower equilibrium for homicide rate. Secondly, with no initial guns there would be no homicides. As more people become criminals they also carry guns with themselves, and therefore, the homicide rate will not remain zero. The simulated pattern of these extreme conditions reflects our expectations.

c) Playing with outlaws

A further presumption is the initial value of 1000 for presence of criminals, who are carrying guns and provoking violent incidents. In the following, we will challenge the model into both extreme conditions, firstly the initial near-absence of criminals[1] and then their excessive initial presence.

Figure shows the simulated pattern of the two extreme conditions as well as the base run. The results are counter-intuitive and caused by model specifics. For the first case, the near-absence of criminals, we expected an absence of violent incidents leading to almost no homicides. However, the behaviour shows an excessive increase in homicides. Moreover the latter case does not meet our expectations. The excessive presence of criminals should lead to a high initial value in homicides which decreases as the number of policemen is increasing. These anomalies are in fact logical, since we need to manipulate the initial number of guns along with the initial number of criminals. These results from an

[1] The total absence of criminals is not possible because of the ratio 'Guns per Criminals' which would lead to a division by zero which is mathematically not defined.

assumption that few armed criminals are more dangerous than many unarmed criminals. An adaptation of the ratio of 'Gun per Criminal' is going to result in more realistic behaviour. Therefore, in our next experiment we change also the initial number of guns so that every other criminal possesses a gun in both cases at the starting point of the simulation. The results of this simulation are shown in Figure 9. Indeed, the behaviour meets our expectation. A higher initial number of criminals with a same ratio of 'Guns per Criminal' implies a higher homicide rate. This leads to a higher police force arresting criminals. The effect of the guns race is still taking place but is therefore lower than in the base run because of the already strong police.

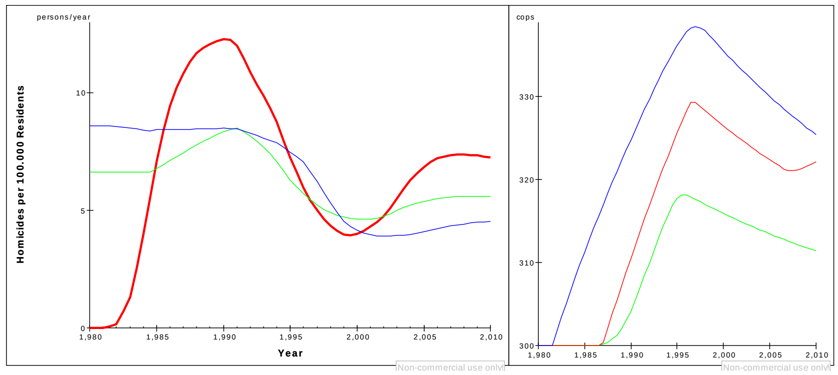


Figure 9. Playing with Outlaws: Left Side: Homicides per Year | Right Side: Police Stock - Legend: green - base run (1000 criminals), red - absence of criminals (1 criminal), blue - hords of criminals (2000 criminals)

The higher than normal homicide rate leads to an accelerated hiring rate which – with a delay – eventually pulls down the homicide rate. In the case of the absence of criminals, the homicide rate is down, but as the drug market shock appears, the stock of criminals start to grow, the arms race takes place and the homicide rate starts to grow. The homicide rate stabilizes eventually because of the presence of police force.

Sensitivity tests

In this section, we are going to study the sensitivity of the behaviour of the model towards changes in three parameters: 'Normal Police Productivity in Confiscation', 'Arms Race Constant' and 'Unemployment within Susceptible Communities'. The first two were identified as important variables in the Structure-Behaviour-Test.

a) *Normal Police Productivity in Confiscation*

For this experiment, we tested the behaviour of the model against 10% changes in the value of 'Normal Police Productivity in Confiscation' in both directions. We expect homicides to rise with less productivity and to go down with more productive police officers. The model behaves logically and according to expectations. It should be noted that the model is quite sensitive to changes in this parameter.

b) *Arms Race Constant*

The 'Arms Race Constant' is a parameter that we use to switch the arms race within criminal communities on and off and to set the strength of this vicious cycle. We observe the model's behaviour with 50% strengthening and 50% weakening of this effect.

Naturally, we should have more homicides with a stronger arms race and vice versa. The following figure shows that the model stands this test well. Figure shows that our expectations are right. A high sensitivity can be inferred.

c) Unemployment within Susceptible Communities

We assumed an initial unemployment of 50% among the major players in the system that we are studying, who are youth living in poor neighbourhoods. In this section, we are going to run simulations to examine the reaction of our structure to improvement and worsening in legal employment opportunities available to these people.

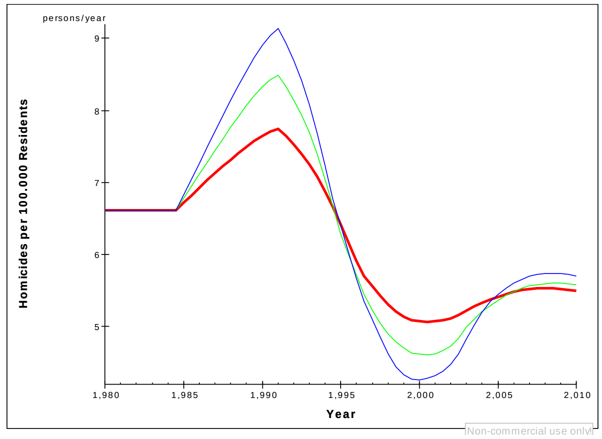


Figure 10. Sensitivity of Arms Race Constant: green - base run, red - 50% (2.75 guns/year), blue - 150% (7.75 guns/year)

The behaviour is quite sensitive to change in the unemployment. Less unemployment leads to fewer homicides. It is in fact logical. First, the motivation is lower to become a criminal since the probability of earning legal money is higher, and, secondly, people have less time to do no good. An increase in unemployment consequently increases homicides. In conclusion, the model reproduces our expectations.

Details of Structure-behaviour Tests

i. Cutting out the arms race loop *R1*

As already stated in the Model Analysis section, cutting out the major reinforcing feedback loop *R1*, representing the 'arms race', removes the capability of the model to reproduce the reference mode, shown in Figure 11.

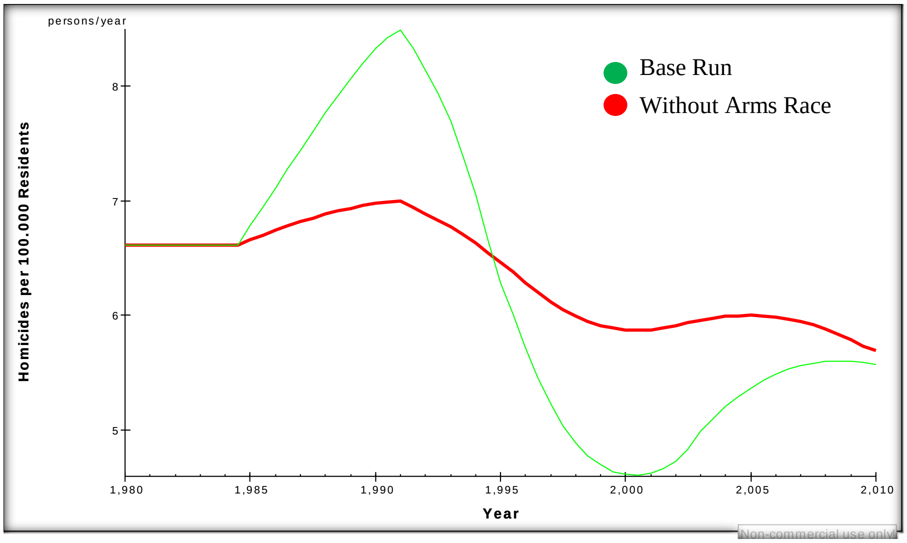


Figure 11. Structure Behaviour Test: Cutting Arms Race

ii. Cutting out All Reactive Adjustments of Police *B3, B4, B5, B6*

If we cut the feedbacks from Homicides to Hiring, to Police Productivity in Arrests, and Police Productivity in Confiscation, the following is the behavior that we will get.

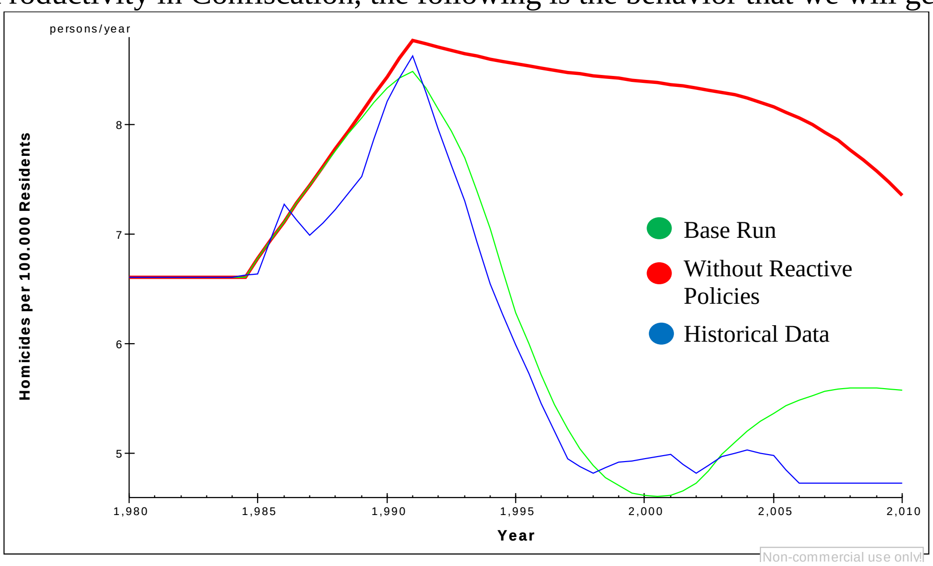


Figure 12. Structure-Behaviour Test: Cutting Reactive Policies

As can be seen in Figure 12, Homicides would start to fall naturally around 1991 when the crack market matures, but it falls at a very slow rate.

iii. Adding the effect of Homicides on Hiring, *B3 & B5*

If we only add the feedback from Homicides to Hiring, we get the following behavior.

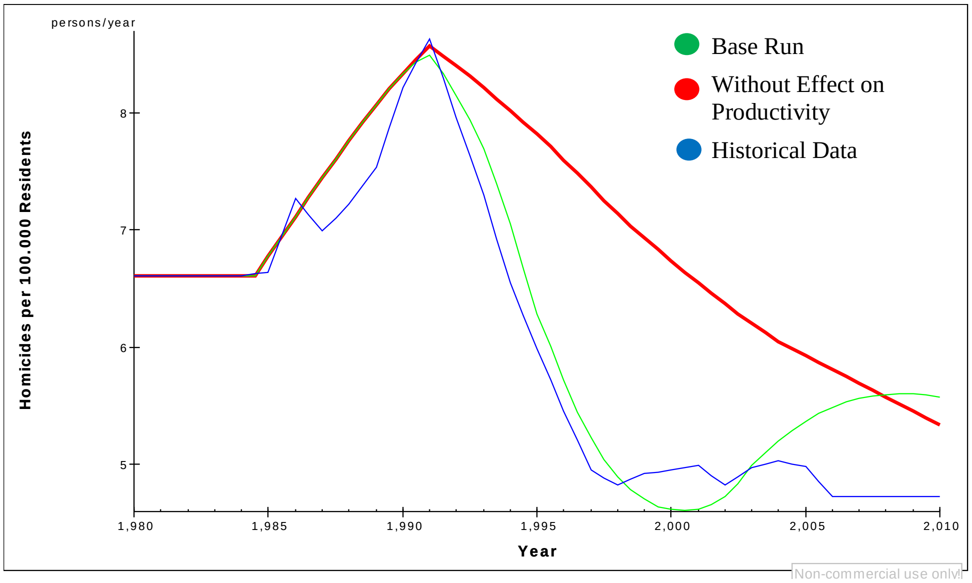


Figure 13. Structure-Behaviour Test: Cutting Effect of Homicide on Productivity B4 and B6

This means that hiring more and more police, without improved productivity, makes a big difference, as can be seen in Figure 13. Still, we have a quite large discrepancy with the historical behavior.

iv. Adding the Effect of Homicides on Police Productivity in Arrests *B4*

If investment is made to improve Police Productivity Arrests, along with the previous policy of increased Hiring the behavior that we get is quite close to the base run.

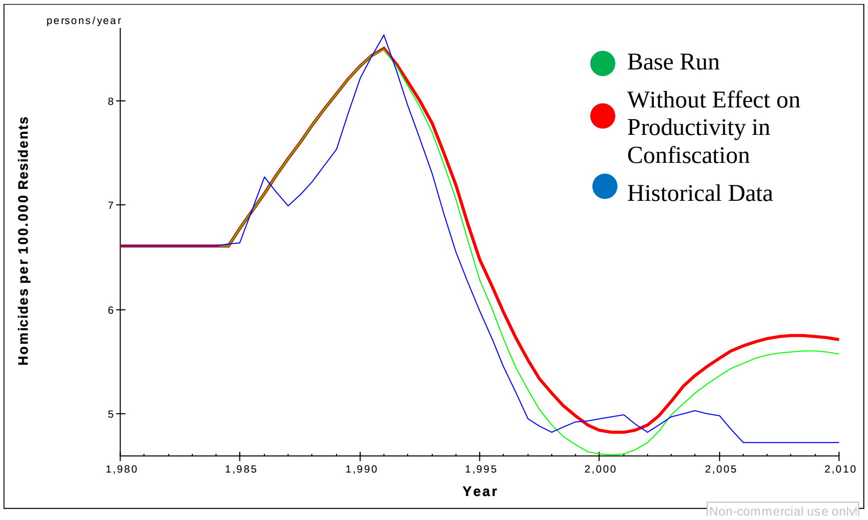


Figure 14. Structure-Behaviour Test: Without Effect of Homicides on Productivity in Confiscation B6

By adding this effect, we get closer to the reference mode. This can be inferred from Figure 14. Right now we only need to add the final Effect of Homicides on Police Productivity in Confiscation to have all feedback loops running and obtain the green line.

v. Cutting out the feedback involving Perceived Risk, *B1 & B2*

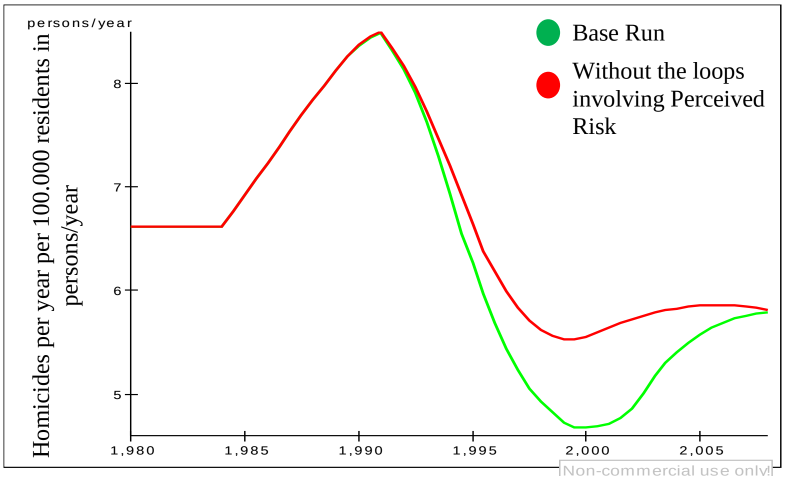


Figure 15. Structure Behaviour Test: Cutting the loops involving Perceived Risk

Figure 15 shows the simulated pattern without perceiving risk as a balancing loop for the 'Criminal' stock. The important change can be seen at the end of the simulation. More homicides will indicate more policemen to be hired, this leads in turn to more arrests. Since there is no perceived risk resulting from these arrests, more criminalization takes place as otherwise would have been. Consequently, homicide rate does not drop as low as otherwise.

Appendix D: Model Boundaries

* Our model assumes a total population of 100,000 residents. All variable values should be regarded with this in mind.

Endogenous		***Exogenous***		***Excluded***
Variable Name	**Description**	**Variable Name**	**Description**	
Homicides	Number of Homicides per Year	Normal Homicides	Starting & Reference Value for Homicides in the model	'Abortion' Hypothesis
Criminals				Severity of Punishment for Violent Crimes
Criminalization	Rate at which new people become Criminals	Normal Criminalization	Equilibrium Value for Criminalization	Effect of Education
Arrests				Effect of Culture & Social Upbringing
Perceived Risk	~ in becoming a criminal			Family-Related Homicides
Guns	Illegal guns carried by Criminals			Effect of Demographics and different age cohorts
Acquisition	~ of illegal guns by Criminals	Normal Acquisition	Equilibrium Value for Acquisition	Effect of Criminals' Experience
Confiscation				…
Guns per Criminal	Percentage of Criminals that carry Guns	Arms Race Constant	A 'Switch' to turn on/off the effect of R1 loop	
Violent Criminal Incidents	All violent criminal situations likely to lead to murder (Drug fights, robberies, etc.)			
Police	Number of Police			

Hiring		Normal Hiring	Equilibrium Value for Hiring	
Retirement		Time to Retire		
Police Productivity in Arrests	Number of Arrests per Police per Year	Normal Police Productivity in Arrests	Equilibrium Value for ~	
Police Productivity in Confiscation	Number of Confiscations per Police per Year	Normal Police Productivity in Confiscation	Equilibrium Value for ~	
Effect of Homicides on Police Productivity in Arrests	(further Investment is implicit)			
Effect of Homicides on Police Productivity in Confiscation	(further Investment is implicit)			
Legal Income Opportunity	Yearly legal income potentially available to people susceptible to criminalization	Unemployment within Susceptible Communities		
		Minimum Wage	An estimate of income available to generally low-skill street kids once they get a job	
Effect of Reward Side on Criminalization	Effect of Legal Income Opportunity vs. Potential Profits from Drug Market on Criminalization	Drug Market	A 'Shock' (modeled as a pulse), representing the rise and eventual maturation of the market for crack cocaine	