Criminal Justice Simulation Model (CJSIM):

Technology and the Flow of Criminals in the Criminal Justice System

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Criminal Justice Simulation Model (CJSIM):
Using a Simulation Model to Examine the Allocation of Technology to Improve the Criminal Justice System

Abstract

This paper examines what would happen in the New York's criminal justice system if two primary changes were made. Those changes are an exogenous doubling of the number of new criminals entering the system (new people becoming criminals) and a doubling of the productivity of police officers. These inputs were selected because they represent changes on the front or upstream end of the criminal justice system, and the effects of these changes on the whole system could be observed. Changes in police capacity, number of people in prison and the total number of active criminals are examined to understand the implications that technological improvements that increase police productivity may have on other parts of the criminal justice system.

Introduction

The criminal justice system in New York State is large, complex and diverse. Although referred to as a system, most entities in the criminal justice system operate independently. Separation of functions, such as those of the courts from the DA or police departments, is built into the system to ensure that courts operate independently from the rest of the system. Although cooperation between different parts of the system occurs, the lines of command, budgets and structures of the various entities within the criminal justice system have developed independently over time. As a result, decisions and actions taken in one part of the system have implications for other parts of the system. At the Symposium celebrating the 30th anniversary of the 1967 President's Commission on Law Enforcement and Administration of Justice publication titled "The Challenge of Crime in a Free Society," Henry Ruth said that the two greatest contributions made by the Commission were "(1) recognizing that the criminal justice agencies and processes should be viewed as a system, and (2) stimulating data collection and analysis" (p. 6). This paper examines the influence of resources and technology on the flow of criminals through the criminal justice system in upstate New York from a system dynamics perspective.

This paper discusses the development of a system dynamics computer simulation model that was built to examine the influence of technology on the flow of criminals through the criminal justice system (the model will be referred to as CJSIM). The basis for this model is the criminal justice system in New York State. The model tracks criminals from arrest to adjudication, from their time in jail or prison to parole and probation. Furthermore, the model tracks criminals after release in order to capture and examine the concept of recidivism. The model specifically examines the system-wide implications of technological improvements in different parts of the system and whether improvements in one area will result in performance problems in other parts of the system.

Background on Computer Simulation Modeling in Criminal Justice

The application of quantitative techniques in the Criminal Justice System goes back to the 1950s and 1960s (Blumstein, 2002). Scholars have long recognized the need for tools and techniques to aid decision-makers in understanding the interrelationships between different agencies in the Justice System. Cassidy argues that decisions made in one agency will affect other agencies within the system, (Cassidy, 1985, Cassidy and Turner, 1978). This reason alone justifies the need to take a system wide perspective, enabling each agency to take into account the impact of its own decisions as well as the decisions of others on the whole system.

Blumstein (1971, 2002) reports extensively on the development of JUSSIM, an interactive simulation model of the criminal justice system that contains three basic elements: process stages, flow paths and resources utilized. JUSSIM served as a pedagogic device for understanding the ripple effects of decisions and actions, as well as a planning tool for the justice system that is "largely fragmented among the police, court and correction agencies" (Jacqueline Cohen et al 1973). One of the insights from JUSSIM was the relationship between the prevalence of arrest and the probability of recidivism. Blumstein and Graddy (1982) found significant race differences in prevalence of arrests. Similar rates of recidivism between races was also found, indicating that similarities among individuals in "criminal careers" exists regardless of race.

Jonathan Bard of the Aerospace Corporation (1977) described the use of a system dynamics simulation approach in "assessing the merits of alternative criminal justice policies and procedures" and concluded that a continuation of current practices would lead to a gradual decline in the ability to deliver services and control crime. Brad's repeated experiments with the simulation model led him to uncover the notion that a reduction in the grand jury delay may cause a short-term imbalance between felony trial queue flow rates. Moreover, he found that it could also lead to a trial delay fractionally greater than that first observed.

Shaffer (1976) used system dynamics modeling to examine the criminal justice system in Massachusetts with an emphasis on the courts. However, he did develop a smaller model that included all the components of the criminal justice system and found that increased prison capacity had the greatest impact on reducing crime. At the time Shaffer was doing this work, prison sentences had been substantially reduced due to overcrowding in prisons. Shaffer found that the reason for the impact of prison capacity was due to the deterrent effects of sentences and that by keeping people in prison longer reduced the cycle time for criminals.

The model discussed in this paper was designed to build upon the work that has been done over the last 50 years and begin to develop system-wide maps and models that portray the complexity of the criminal justice system. The final outputs of the model, as well as the process of building the model, should help decision-makers gain a better understanding of the criminal justice system, enabling them to formulate more effective policies for better performance.

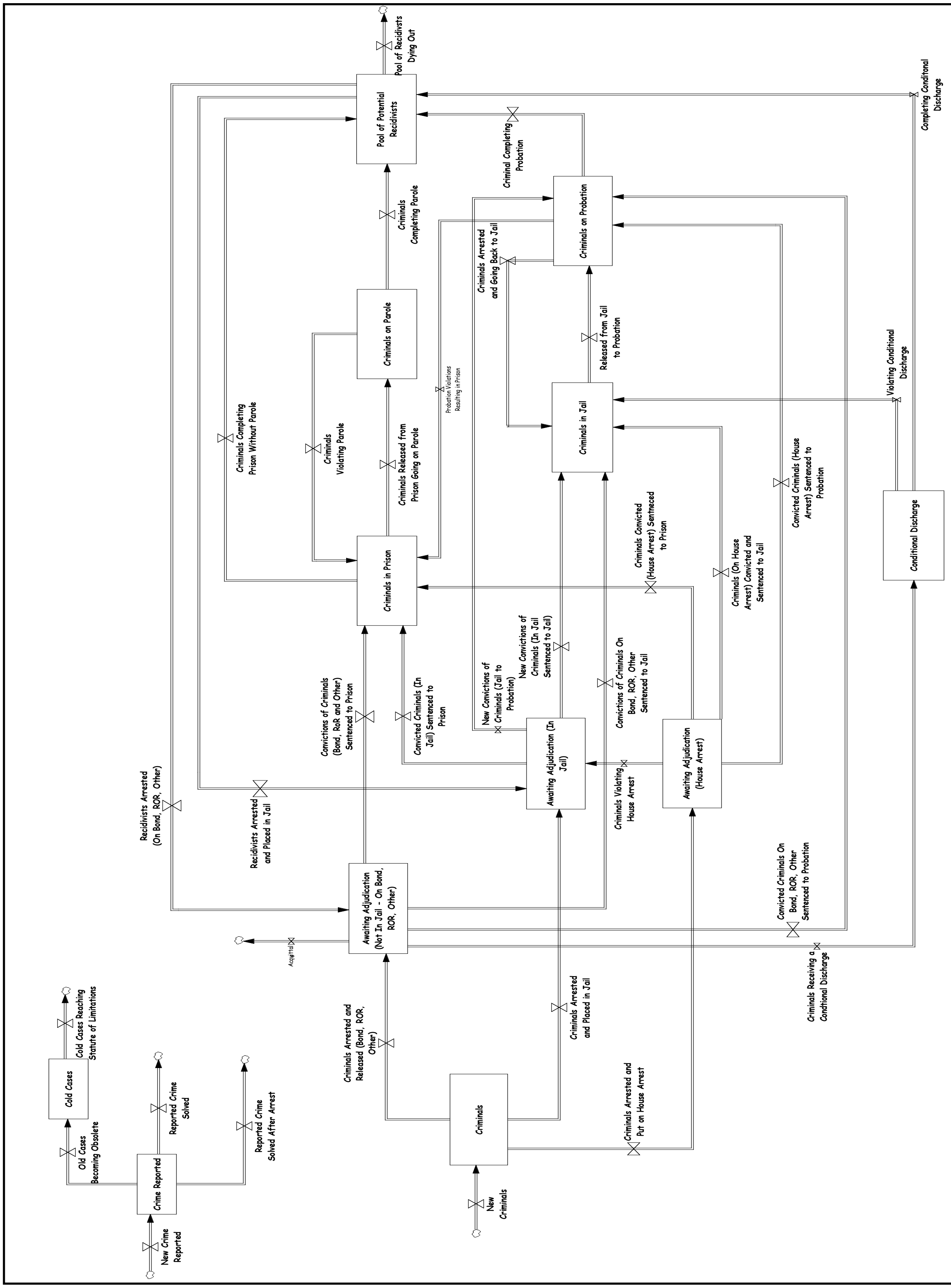


Figure 1: Stock and Flow Overview Map Developed by Experts

Modeling Process

The modeling process was initiated through open-ended interviews with experts working in the system. These experts worked in the system as police officers, sheriffs, DAs, judges, probation officers, parole officers, and those working in the New York State Division of Criminal Justice Services. The primary purpose of these interviews was to develop a stock and flow map of how criminals moved through the system, from the time a crime was committed until they were released from any and all sanctions after capture and conviction. Data for the model were obtained from publicly available information sources published by different government agencies involved in the criminal justice system.

At each interview, participants examined the current stock and flow diagram. An explanation of what they were looking at was provided, followed by a discussion of whether the places criminals could flow to were accurately captured in the diagram. Interviewees were then asked if, in their opinion, there were other places that criminals could flow. The changes related to their suggested additions and/or "subtractions" were then physically drawn on the map. For the boxes (i.e., stocks) added, the interviewees were then asked where the criminals in those boxes could flow to. For example, upon release from prison where do criminals go? Criminals can be released from prison and go to parole or they can move into a stock labeled Pool of Potential Recidivists. Furthermore, the participants were also asked to identify the sources where criminals came from before flowing into each box. The participants were also asked to identify what resources were needed in order to facilitate or control the flow of criminals from one stock to another. For example, in order for criminals to move from jail awaiting adjudication, resources from the DA's office and the courts would have to be used. Focusing on the area in which they worked, the participants were then asked about the types of decisions they made and what information they looked at to make those decisions.

This process was followed with all participants interviewed. As the process progressed, fewer and fewer changes were made to the map. By the end of the interview process, a consensus on the stock and flow structure of the model was reached, with discussions confirming that no further structural changes to the map were needed.

Figure 1 contains the completed stock and flow map[1] of the flow of criminals through the criminal justice system in New York State, as identified by experts in the criminal justice system. The left hand side of the diagram shows criminals not yet known to the system. These are people committing crimes who have never been caught. Once criminals are caught, they move through the system from left to right in Figure 1. After arrest, criminals await adjudication in one of three places. These boxes capture criminals Awaiting Adjudication (In Jail), Awaiting Adjudication While on Bond - Released on Own Recognizance (ROR), or Awaiting Adjudication (House Arrest). From there, people can move to criminals Conditionally Discharged, Criminals in Jail, Criminals in Prison, Criminals on Parole, and Criminals on Probation. All of these folks are under some form of sanction from the criminal justice system. While criminals in jail and prison

[1] This is the map that experts came to a consensus on. Acquittals may occur regardless of where people are held after arrested. However, acquittals are not shown as an outflow from criminals on House Arrest or Awaiting Adjudication in Jail. This was done in order to simplify the map.

cannot commit any additional crimes while incarcerated, criminals on probation, parole and on conditional discharge can commit additional crimes or violate the conditions of their sanctions and can move immediately to jail or prison. [2]

Parole is also considered a sanction, but criminals can only be on parole after serving time in prison; thus they move from prison to parole. From parole, criminals can be sent back to prison or they can successfully complete parole and move into the Pool of Potential Recidivists. Although not explicitly shown in Figure 1, the Pool of Potential Recidivists is broken down into two pools of recidivists based on time. Recidivism rates for those criminals making it through the first five years of release is lower than for those within the first five years of release. Disaggregating these in the model allows for the tracking of these two groups and for the assigning of different recidivism rates for these groups. Furthermore, once people have been arrested, convicted, sanctioned and flow into the pool of potential recidivists, they are considered potential recidivists for the rest of their lives.

With the map of the system complete and agreed upon, the process of taking the feedback loops identified by experts and incorporating them into the model began. Information obtained through the open-ended interviews was combined with knowledge gained from the literature to develop the feedback loops incorporated in the model. Data was collected from a variety of publicly available sources to set the initial conditions. The formal model was tested at each stage in order to understand the behavior generated from sub-sectors before they were added to the overall model.

The Formal Model

CJSIM[3] is a system dynamics computer simulation model developed from the sources described above. The formal model captures the flow of criminals through the criminal justice system. For the purposes of this paper, one scenario and three tests of technology were used to examine the implications on different parts of the criminal justice system. The scenario test increased the number of new criminals entering the system by 100 percent at time 20. Although extreme, it was felt that this shock to the system could be performed under conditions when resources were fixed and when resources were flexible, which would provide information related to time delays in the system, from the time of arrest until the criminal ended up in the pool of recidivists from which they have the opportunity to recidivate. An additional test focused on improvements in technology at different points in the system, of which the initial influence should be to increase the number of people in the system through police enhanced technology or improvements in DA/Court processes or supervision of criminals on probation and/or parole. New technologies that work should result in more arrests, convictions, or violations until criminals learn about the ef-

[2] Crime can be committed while criminals are incarcerated, but these crimes were considered to be outside the model boundary for the purposes of this model.

[3] Complete stock and flow diagrams and the equation listing for the model can be obtained by contacting the authors.

fectiveness of the new technology and change their behavior to either evade detection or stop the criminal activity.

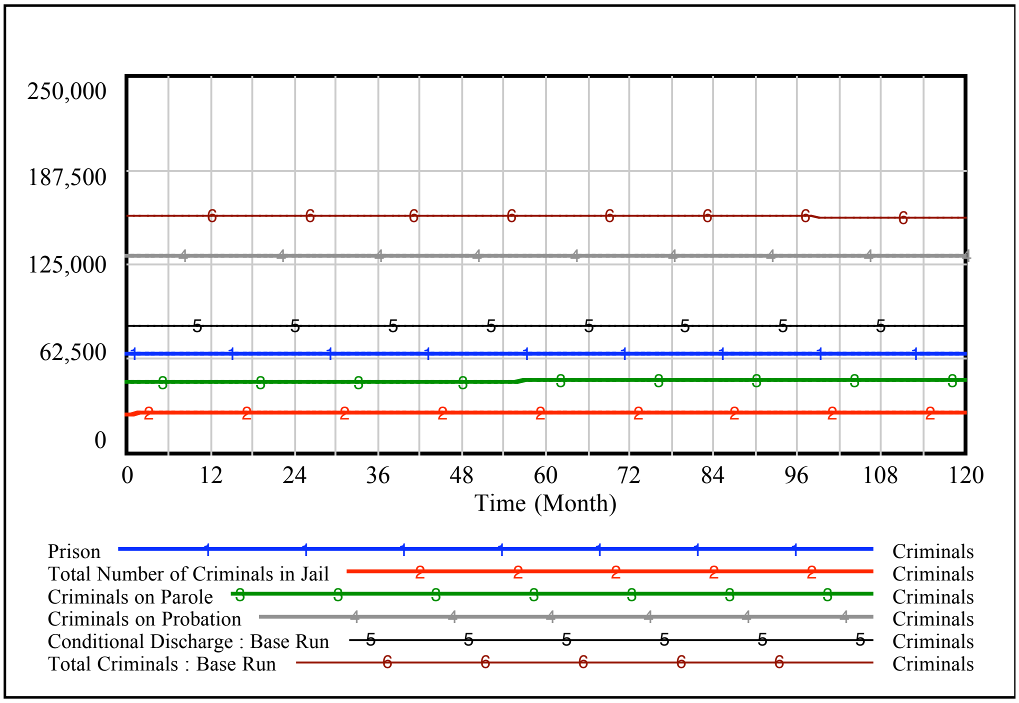
Equilibrium Model

A system dynamics model is in equilibrium when all the inflows equal all the outflows for all the stocks in the model. Each stock is unchanging and, as a consequence, all model variables are unchanging over time (Richardson and Pugh, 1981). This is not to say that criminals do not continue to flow through the CJSIM model, rather, new criminals moving into a stock are equal to those moving out of that stock. System dynamics models are put into equilibrium for the purpose of analysis and understanding (Sterman, 2000). By starting in equilibrium behavioral changes that result from changes in parameters and/or structure of CJSIM can initially be analyzed in isolation and behavior and structure can be linked more efficiently. Although simulating the model in equilibrium means that the historical data for New York State will not be replicated, it should be noted that the initial numbers used in the model were obtained by taking the average number of criminals in jail, prison, on probation and on parole over the 1999-2004 time period, the most recently available data at the time.

Simulation of CJSIM in Equilibrium

Graph 1 contains simulated output for Criminals in Prison, Total Number of Criminals in Jail[4], Criminals on Parole, Criminals on Probation, Criminal Conditionally Discharged and New Unknown Criminals. These variables were selected as indicators of what is happening at each of these points in the criminal justice system where criminals are under some form of sanction and consume system resources. Any variable in the model may be examined to observe its behavior over time. Furthermore, by starting in equilibrium, a base run from which changes can be compared is available.

[4] The Total Number of Criminals in Jail is made up of criminals in jail awaiting adjudication and criminals sentenced to jail after conviction.



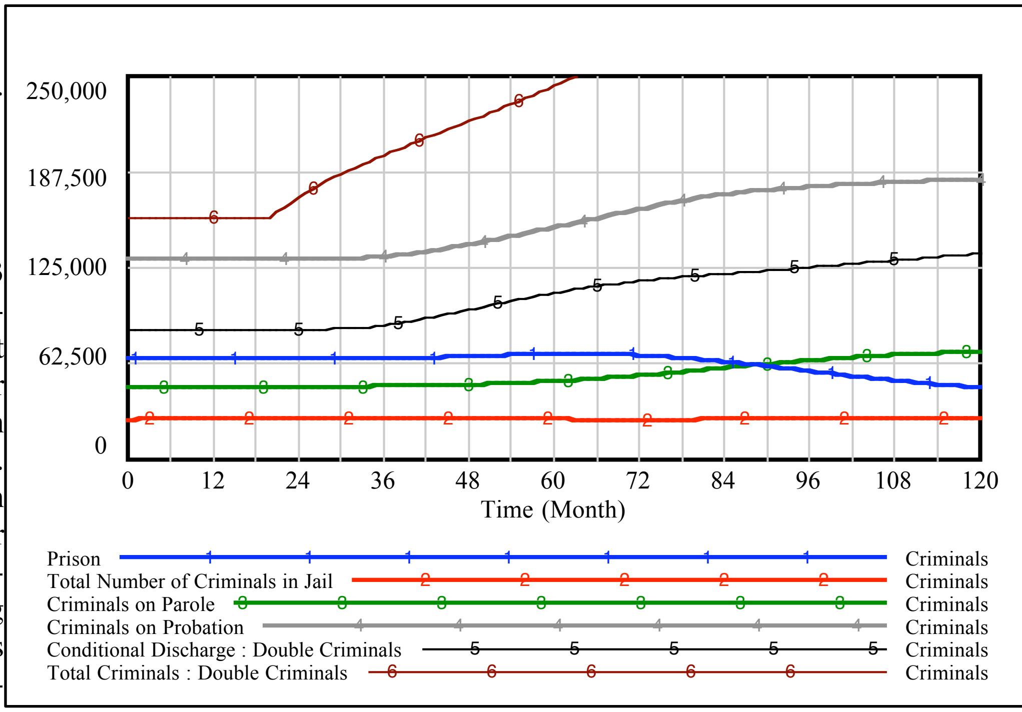
Graph 1: Criminals Under Sanction

Scenario 1

The first scenario involves doubling the number of new criminals entering the system at month 20. The simulation results for this scenario are shown in Graph 2. The number of Criminals on Probation[5] increases as does the number of Criminals on Parole, and the number of Criminals Conditionally Discharged. This is expected. As more criminals enter the system, the number of Total Criminals overwhelms the capacity of the police to make arrests and grows off the scale.

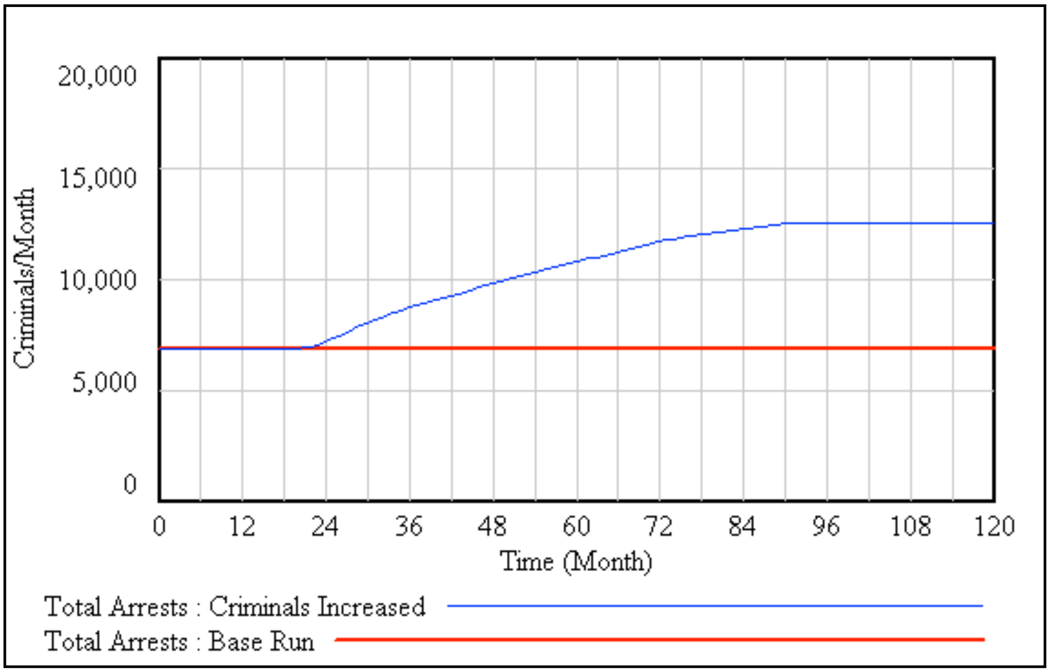
[5] The convention that variable names are capitalized

Graph 2: Doubling the Number of New Criminals



Graph 3 contains information about the number of arrests in the model. Although the number of criminals entering the system as new criminals doubles, the number of arrests also doubles. The number of Total Criminals (this is active criminals under no sanctions in the system) also continues to increase. This is due to a number of factors. One factor is resource constraints in the police sector. Although police resources remain the same, additional arrests are made for two primary reasons. First, there are more active criminals (the Total Criminals variable and the Crime Solving Loop in Figure 2), and thus crime committed increases, and it becomes easier for police to arrest criminals as there are more of them. Second, the increase in crime generates command pressure (The Command Pressure Loop in Figure 2) on police and that leads to additional arrests. This command pressure could take the form of overtime or the shifting of resources so that more police are patrolling and undertaking investigations. However, there are limits to how much can be accomplished, and there is not enough slack in the system to accommodate the additional criminals and crimes generated. Hence, when the flow of new criminals into the system is greater than the ability of the police to make arrests, the number of Total Criminals grows.

Furthermore, when a new Unknown Criminal is arrested for the first time, they become known to the system, serve some form of sanction, and then move into the pool of potential recidivists from which they are likely to be arrested again. Therefore, the introduction of a new criminal into the system results in police resources being required to deal with the initial crime and, then due to recidivism, they will deal these people again later. The problem of criminal behavior is not solved for most criminals with one arrest. They become known to the system, but continue to commit crimes when they are not under the sanction of jail or prison in the model.



Graph 3: Number of Arrests

Figure 2 contains two negative feedback loops, the Command Pressure Loop and the Crime Solving Loop, described above. The negative feedback loops compensate for the increased number of criminals in the system by placing pressure on the police to do more with the resources they have.

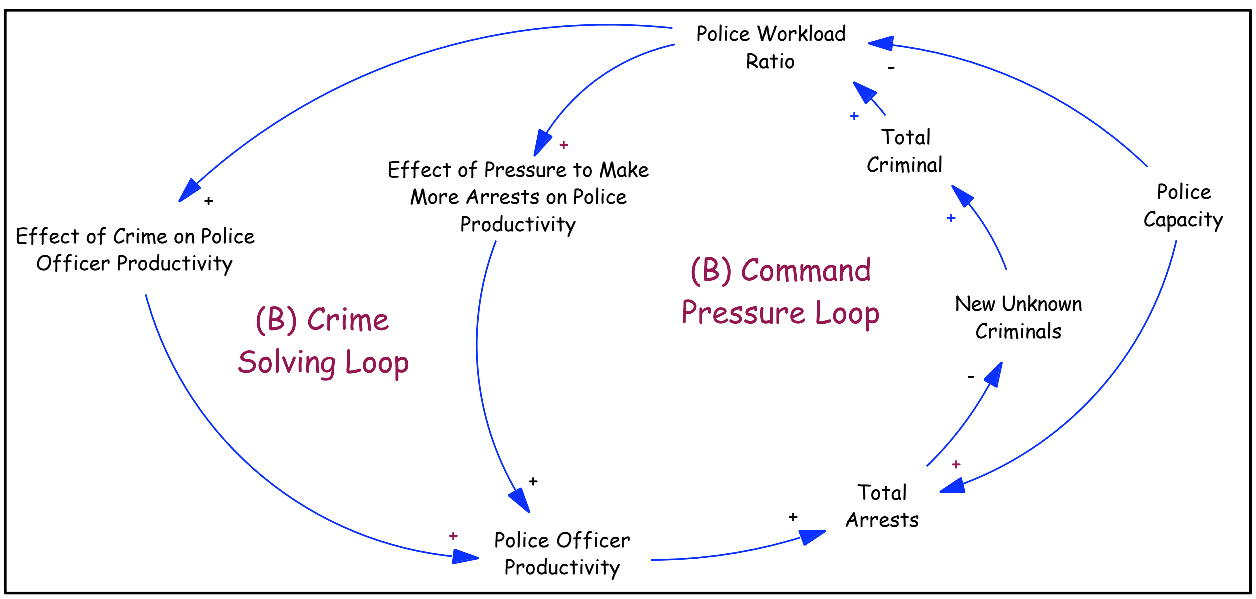
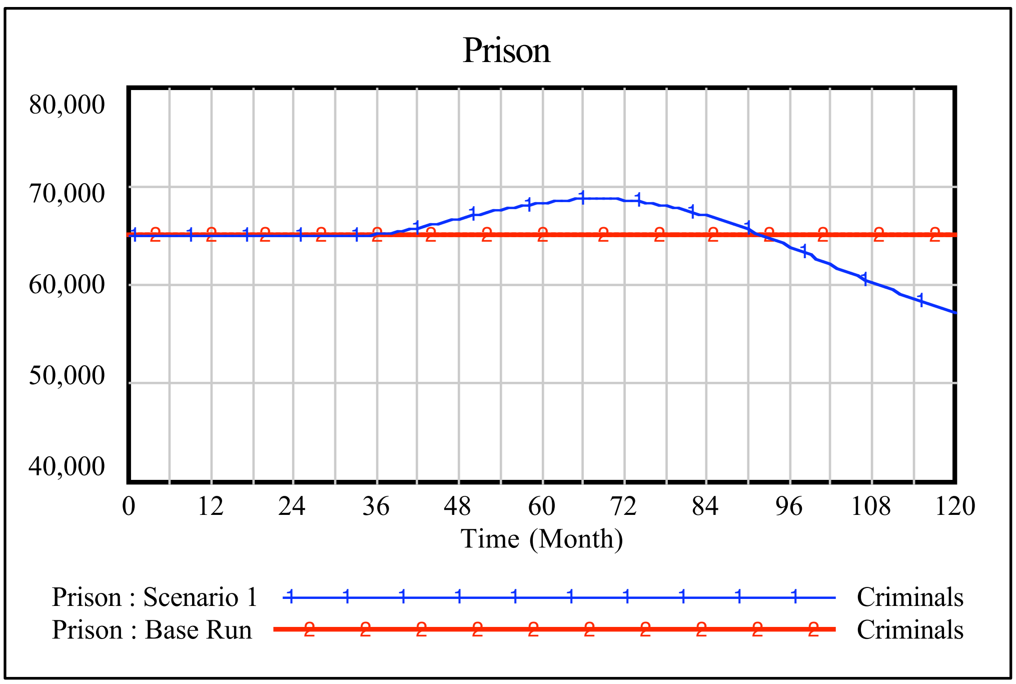


Figure 2: Feedback Loops Around Police Workload

Graph 4 shows changes in the prison population in the base run and when criminals in the system are doubled (Scenario 1). As expected, the increase in criminals in the system results in additional criminals being sentenced to prison and the prison population increases. However, over time the number of criminals in prison falls and, after 90 months, is below the equilibrium condition for the number of criminals in prison. The reason for this, in the model, is that resources throughout the system are not increased. The same number of police, DAs, judges, jail and prison cells, and parole and probation officers remain constant in the system. The compensating feedback loops in Figure 2 results in more arrests, but the DA / Judicial sector of the model cannot keep up with the additional work. Figure 3 contains feedback loops associated with the DA / Judicial sector of the model.

As the DA / Judicial Workload Ratio increases, it increases pressure for the DA to take action. The DA thus increases the number of plea bargains by offering shorter sentences to criminals. The shorter sentences work as an inducement to criminals to resolve the case quickly, thus reducing the DA / Judicial Workload Ratio. More cases are resolved and in the short-run prisons end up with more prisoners, but the sentences are not as long and the shortened sentences result in the overall decrease, after some time, in the prison population.



Graph 4: Prison Population in Base Run and with Increased Criminals

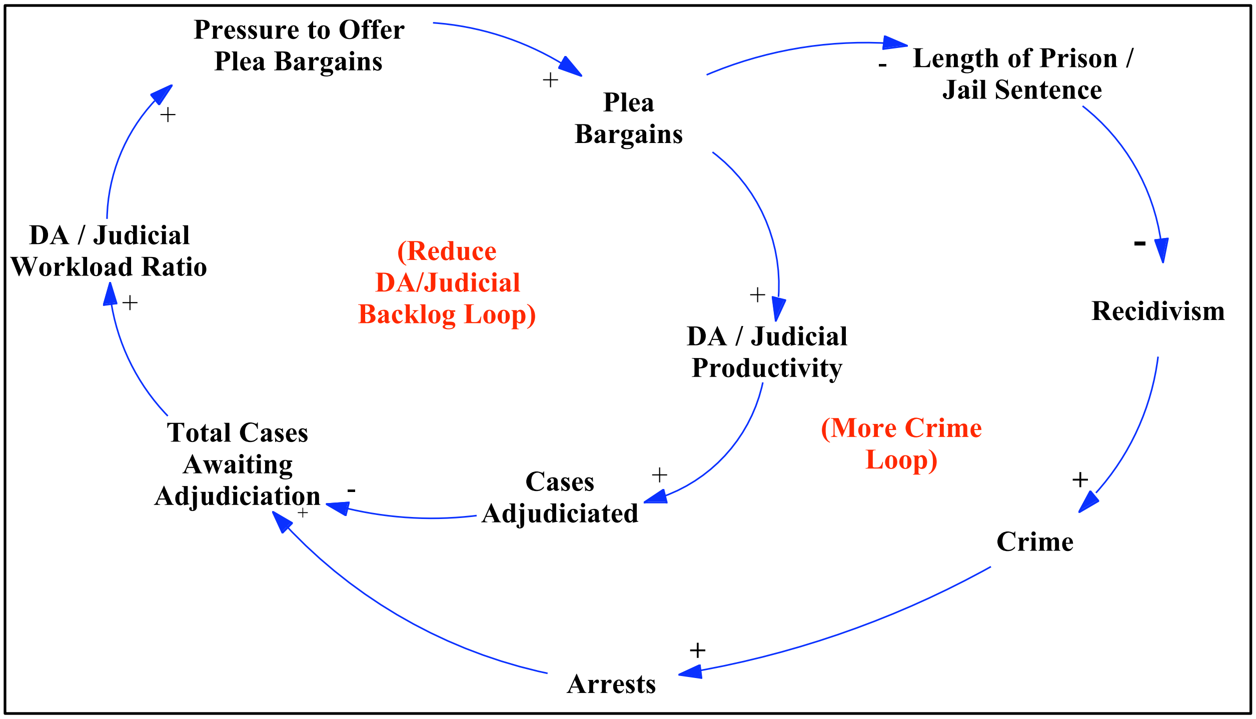


Figure 3: DA / Judicial Sector

Technological Improvements

Technological improvements in the criminal justice field can take various forms, ranging from improved police communication, better evidence handling, new monitoring techniques in jail or prison, and/or better monitoring techniques or treatment programs when criminals are on probation or parole. For the purpose of model analysis, technological improvements have been added to the model in the form of productivity improvements[6]. This captures those technological improvements that will result in increased movement of criminals from one place in the system to another. For example, technological improvements that allow police officers to become more efficient will allow them to make more arrests in a given time period. This will result in more criminals needing adjudication, and more criminals going to prison, jail, probation and parole, if all other things are held constant.

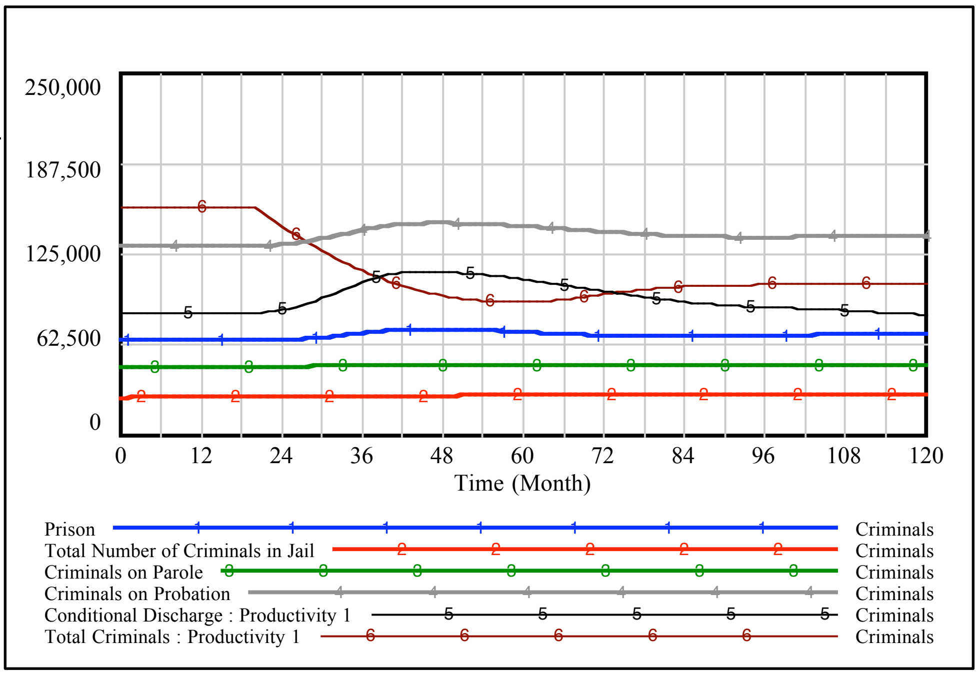
Improved Police Productivity

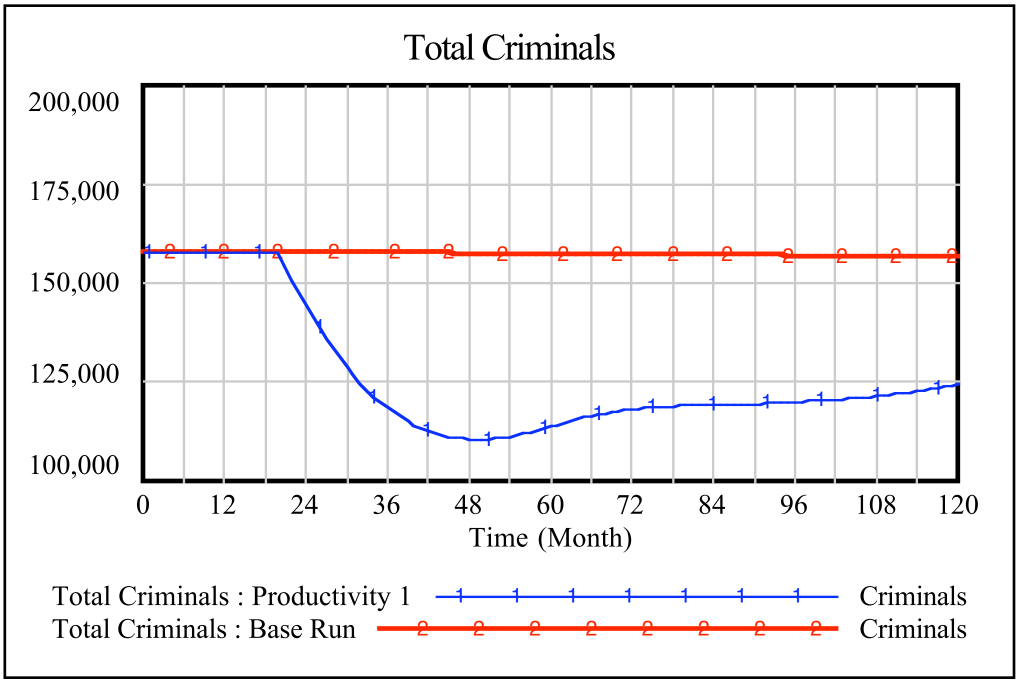
The model was structured so that police productivity could be increased at month 20 by changing one model parameter. Graph 5 contains the output from increased police productivity to what is

[6] A second model has been developed that specifically addresses the issue of technology aiding productivity. In interviewing folks from different agencies, it became apparent that some technologies generate more work, not only in the short-run due to a learning curve, but in the long-run. Monitoring devices can now be placed on individuals and parole, probation or those supervising people under house arrest will be notified when violations occur. This requires additional work on the part of those monitoring. Furthermore, forms of technology, although electronically recorded, require the review of people in order to capture violators. These reviews were not previously required as the technology did not exist (interlock devices for felony DWI offenders is an example). Although this will be reported in a different paper, it is worth noting here.

assumed to be technological changes that will allow the police to catch more criminals. Police productivity was increased by 50 percent in the simulation run below. The results are not as dramatic, given the 50 percent increase in police productivity, as observed in the increases in the number of criminals in prison, on probation, on parole and conditionally discharged. The number of criminals in jail remained the same since jail capacity was at a maximum in the base run. So additional arrests do not lead to more criminals in jail due to capacity constraints. However, the number of Total Criminals (these are active criminals not under any sanctions) decreases and then starts to come back, leading to a decrease over the time of the simulation of approximately 28,000 or 18 percent (Graph 6 shows only Total Criminals for the Base Run and Police Productivity 1 run). The decrease and then increase in Total Criminals is due to additional arrests, which leads to more criminals being under some form of sanction. However, criminals eventually get released and some of these criminals recidivate, becoming active criminals, and thus push up the number of Total Criminals near the end of the simulation run.

Graph 5: Criminal Locations After Increased Police Productivity



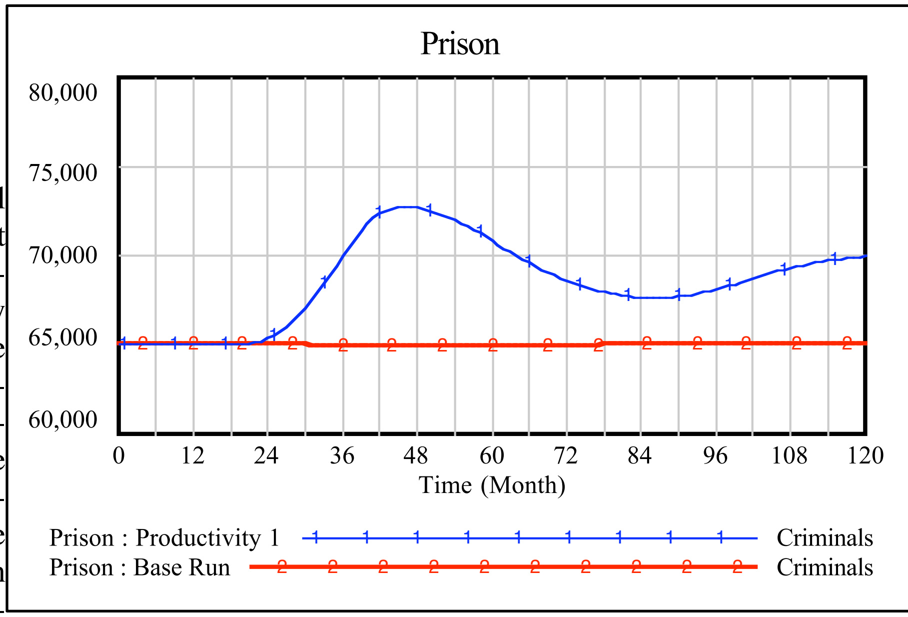


Graph 6: Total Number of Criminals in the System

It was anticipated that a 50 percent increase in the productivity of police would lead to a substantial decrease in the number of Total Criminals with a subsequent and offsetting increase in those held in prison, parole, probation and conditionally discharged. There are a number of reasons in the model for the changes observed in Graph 6. First, resources in the system were allowed to vary[7]. Additional arrests by the police created stress downstream, but downstream resources were allowed to increase. The DA/judicial sector were allowed to increase capacity as were parole, probation, jails and prisons. The oscillation of the prison population observed in Graph 7 is generated by the long time delays in bringing brick and mortar resources on line as with the construction on new prison cells.

[7] The desired resources for DAs, jails, prison, probation and parole were structured based on a normalized workload ratio. If the workload ratio were equal to 1 then the amount of work to do was considered to be normal. If the workload ratio were above 1 then the amount of work to do was above normal and would require additional resources. If the workload ratio were below 1, then there were too many resources for the work to be performed. Varying resources means that resources in the model were allowed to change, after an appropriate time delay, so that the workload ratio would move back to 1.

Graph 7: Prison Population



The model was structured so that Desired Police Capacity was determined by Total Criminals, Police Productivity, and an Initial Average Time to Arrest. The captured the concept that resource allocations in the police sector would be based on how long it took, on average, to solve crimes. Figure 4 captures a simplified version of this negative feedback loop. The increased police productivity results in two effects. First, as police become more productive, fewer officers are needed to do the same job. Second, as police become more productive, Total Arrests increase and, in turn, Total Criminals and thus Crime decrease, resulting in a decrease in the Desired Police Capacity. The police sector in the model can capture the technological improvements that generate increased productivity by reducing police capacity (manpower). This raises a caveat about how different sectors of the system will react to technological improvements that increase productivity. There will be more people in the system, but resource allocation decisions will push back in order to capture savings as a result of the productivity improvements due to technology.

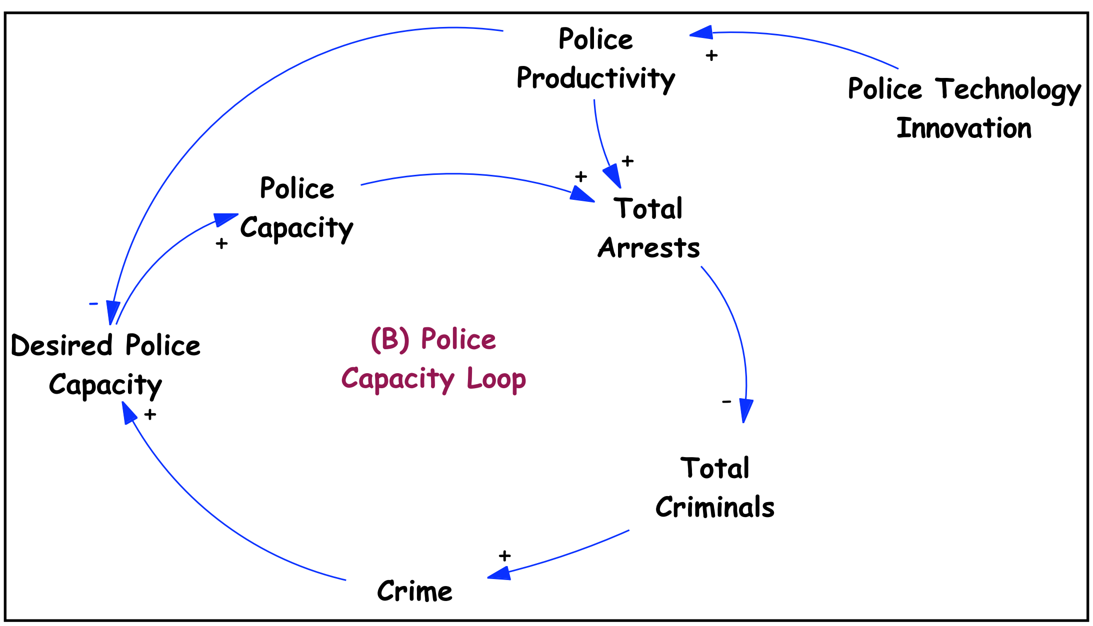


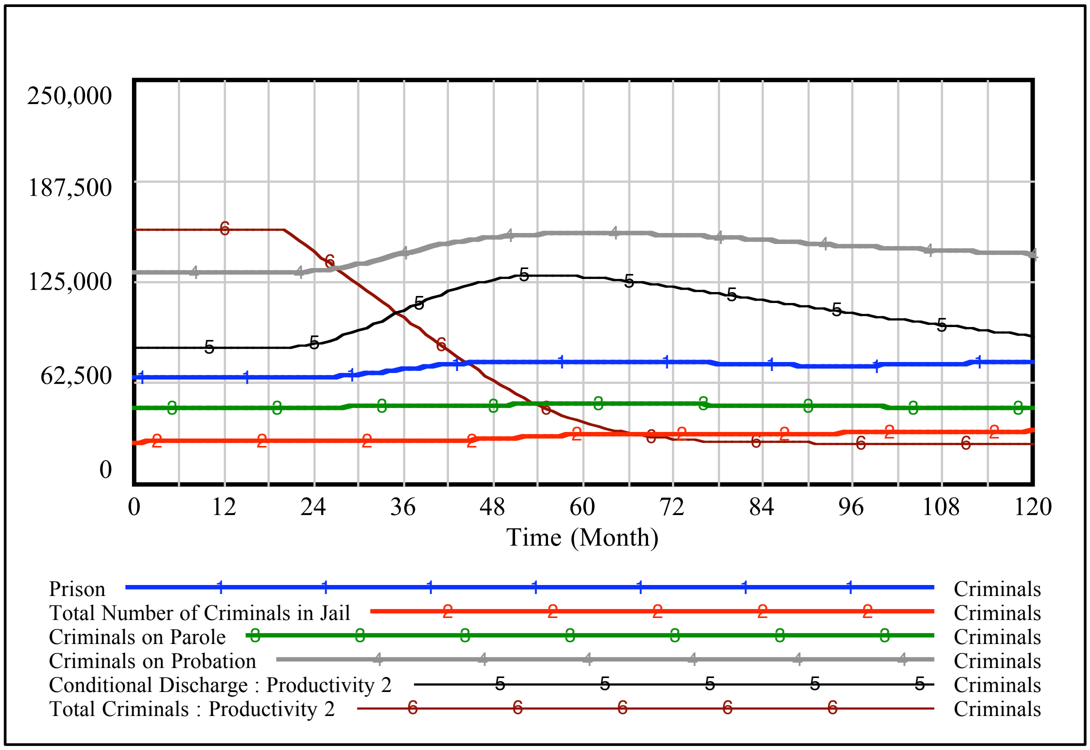
Figure 4: Police Capacity Loop

After it was realized that the Police Capacity was being reduced in the model, structure was added so that Police Capacity would remain constant regardless of productivity improvements and the Desired Police Capacity[8]. The number of Total Criminals in this simulation run were substantially reduced when the police sector was not allowed to reduce Police Capacity[9] (these simulation runs are labeled Productivity 2). Police were able to make 50 percent more arrests, as long as criminals existed and crime continued. Police productivity improvements resulted in more arrests since the productivity improvements were not translated into a reduction in Police Capacity. The results for this simulation are shown in Graph 7. This time there is a substantial reduction in the number of Total Criminals in the system and an increase then a decrease for Criminals on Probation and on Conditionally Discharged. Criminals in jail (Total Number of Criminal in Jail) and on Parole increase slightly and the criminal in Prison show a slight oscillation (This can also be observed in Figure 7 under the Productivity 1 run), and the Total Number of Criminals in Jail.

One of the things occurring in the model is that stress in the downstream part of the system is increased. Productivity increases in the police sector result in more arrests and more criminals are fed into the criminal justice system. This creates strains in the various parts or sectors of the system, including the DA / courts, prisons, jails, parole and probation. Each of these sectors has compensating feedback mechanisms whereby plea bargains, early release policies, etc. are put into effect in order to reduce workload stress in that part of the system. Because of this effect, the numbers of Criminals on Probation and Criminals Conditionally Discharged increase substantially compared to the base run.

[8] This was done in the form of a switch that allowed us to turn off the ability to change the number of police. Police became a constant.

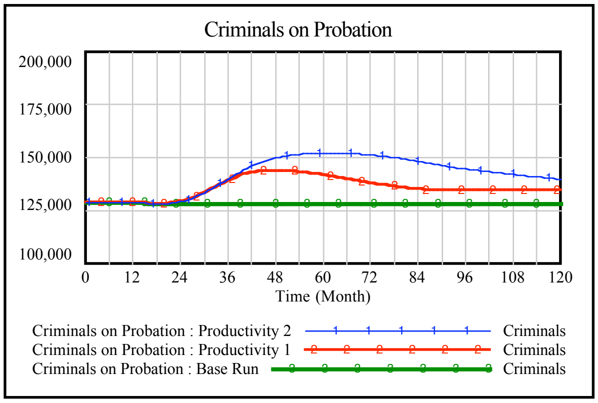
[9] Experts from the New York State Division of Criminal Justice argued that this made sense as most police in New York State are union members and that police unions are strong and that reduction in force due to increased Productivity or a reduction in overall crime would occur gradually as police retired and were not replaced.



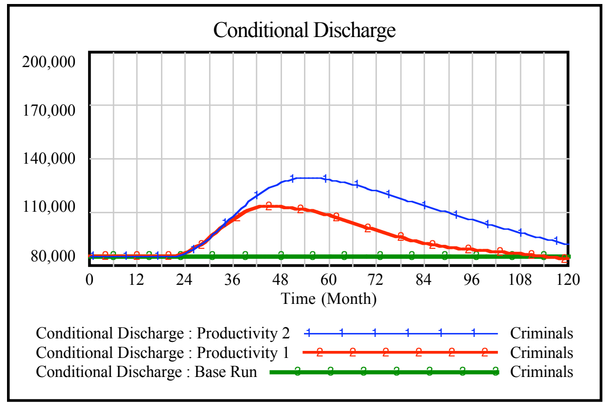
Graph 7: Increased Police Productivity with Police Capacity Held Constant

Graphs 8 and 9 capture the number of Criminals on Probation and Criminals Conditionally Discharged for the base run, the police technology run when Police Capacity was allowed to vary, and for the police technology run when Police Capacity was not allowed to vary. There are substantial differences in the simulation runs (labeled Productivity Runs 1 and 2) under the constraints described. Criminals on Probation increase before declining; Criminals Conditionally Discharged increase and then begin to decline toward the end of the simulation run. The additional arrests generated by increased police productivity move more people into the system and under some form of sanction. The majority of these criminals end up on probation (Criminals on Probation) or are conditionally discharged (Criminals Conditionally Discharged) as they do not have the resource constraints of jail and prisons. Furthermore, only criminals sentenced to prison can end up on parole, so prison ends up as a buffer that limits the number of Criminals on Parole.

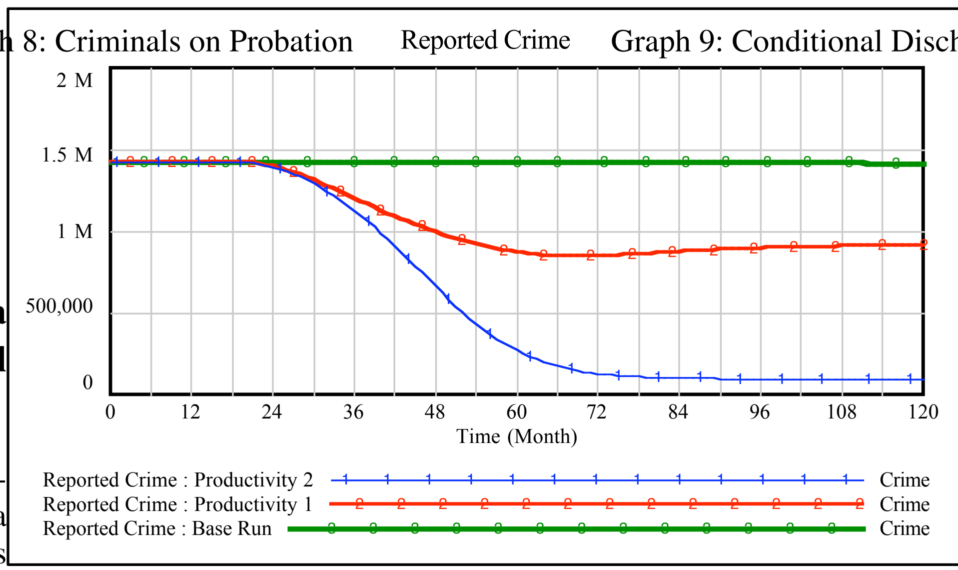
Although the increase in police productivity does not seem to lead to dramatic increases in the number criminals in the system in terms of criminals in jail, prison, on probation or parole, the decrease in crime in the model is dramatic (Graph 10). This dramatic decline is due to the number of new criminals entering the system on a monthly basis. This number is unknown as people deciding to become criminals do not indicate their intentions. However, estimates can be made since the number of people in the system in jail, prison, on probation and parole is known, as is information about their average lengths of stays in each of these locations. The number of new criminals entering the system in the model is initially 3,318. This number generates the number of criminals in jail, prison, on probation and parole that are reasonable for New York State. Other variables in the model, such as the probability or time it takes to capture a criminal, also influence this number. The point is that this number is reasonable, but further analysis needs to be conducted. However, it also points out that a careful selection of the variables examined to determine the success of productivity improvements is very important, as the number of people in the system does not seem to increase by much, yet there is a dramatic fall in crime.



Graph 8: Criminals on Probation



Graph 9: Conditional Discharge



Graph 10: Reported Crime Compared

Data and Model Limitations

As previously stated, a system dynamics model represents a theory about a particular problem. The theory is developed from discussions with experts in the criminal justice system in New York State, a review of the available data, and other reports. Although relevant data is available and is collected from a variety of sources in New York State, there were data limitations.

Since the focus of this study was to explore how criminals flow through the criminal justice system and how technology could influence the flow of criminals, the lack of information about the actual number of new criminals entering the system is unfortunate. This number is backed into by using information available in other parts of the model. Furthermore, there were discrepancies between what people said and the data. The experts interviewed on the investigation side all claimed that the vast majority, about 99 percent, of all arrests lead to convictions. However, when matching the model against actual data, it was discovered that police make approximately 514,000 arrests per year and that the court system adjudicates about half that number of cases. It is unclear at this point whether people are arrested for more than one offense and the DA / court system combines charges and adjudicates on only one of the charges or whether the DA / court system declines to prosecute individuals for some reason. This will be explored further in future analyses and the appropriate model structure will be added.

Discussion and Summary

As noted above, the computer simulation model for this study was developed based on a review of the available data and the information gathered in discussions with experts responsible for different parts of the system. The model was initialized in equilibrium so that behavioral changes resulting from changes in inputs could be understood and analyzed. The initial values were selected to represent the average number of criminals in different parts of the New York State corrections system between 1998 and 2004. All changes in inputs were implemented at month 20 so that the initial equilibrium conditions could be observed and then the effects of changes could be examined.

This paper examines what would happen in the New York's criminal justice system if two primary changes were made. Those changes are an exogenous doubling of the number of new criminals entering the system (new people becoming criminals) and a doubling of the productivity of police officers. These inputs were selected because they represent changes on the front or upstream end of the criminal justice system, and the effects of these changes on the whole system could be observed.

Doubling of new criminals entering the system does not result in a doubling of arrests made by police officers. The number of arrests increases substantially as police in the model have the ability to adjust their level of effort, which is driven by workload pressure. However, their ability to adjust their level of effort is limited. They cannot keep up with the number of new criminals entering the system, and thus crime increases as police are unable to clear all the new cases. Although more criminals are arrested, the number of people in prison (Graph 4) initially increases and then decreases. This occurs because an increase in criminals arrested causes an increase in the workload of the DA/Judicial sector participants. In order to deal with the increased workload, with fixed resources, plea bargains are increased. The immediate effect of more plea bargains is to reduce the time it takes to deal with a case. As a result, the DA/Judicial sector processes more cases with the given resources. However, in order to increase plea bargains, the DA/Judicial sector must offer better deals to criminals which means shorter sentences and, on the margins, a movement from incarceration to probation. This results in an initial increase in the number of people in prison, but a decrease in the long-run as the sentence length was shortened as part of the increased pressure for plea bargains.

The doubling of police productivity had a number of effects. In the model, police capacity was structured as a goal setting activity in that the number of police was determined by the police workload, which is the amount of crime divided by the number of police and this in turn was divided by a normal workload. This resulted in an increase or decrease in the number of police based on the amount of unsolved crime reported. When police productivity was increased, and police were allowed to change, the number of police was reduced. The gain in police productivity resulted in additional arrests, but this decreased the amount of unsolved crime reported and the number of police was reduced. Improved productivity can result in one of two basic outcomes. If the number of resources allocated to a given task can be kept constant, the productivity gains will result in more being accomplished or the benefits of the improved productivity can be consumed by the affected area through reduced resources while maintaining the same level of output. These possible outcomes point to the concept that in all areas of the criminal justice system there may be a locally determined set of goals about acceptable productivity. An unanswered question (unasked during this project) is how would increased productivity change the goals of acceptable productivity in the short and long-run? Will the savings from productivity increases result in smaller staff, people accomplishing more, or increased activities not currently undertaken?

The doubling of police productivity did not have a significant impact on the overall number of people under some form of supervision in the model. This was due to the feedback effects of the downstream entities compensating for the increase in their workload due to increased arrests. Furthermore, increased police productivity substantially reduced the number of new criminals in the system committing crime. In turn, this reduced police productivity as there was less crime to solve. This finding raises additional questions. One of the unknowns in the system is how many unidentified criminals (not recidivists) are entering the system for any given time period. Once the police arrest more of these people than are entering, a reduction in the number of unsolved reported crimes will result. Further work needs to be undertaken to determine whether the number of new criminals entering the system is realistic or a result of the analytic equilibrium.

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