Overview, Design Concepts, and Details (ODD) for the Effect of Policy on Juvenile Delinquency Rate within a Predefined Community Model

Aiming Nie | Guhan Wang | Qi Wu

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1. Purpose

A poor community in Georgia has been experiencing high juvenile delinquent rate over the past few years. The local government of that community came to us for suggestions to reduce the overall juvenile delinquent rate. Based on research journals about reducing crime and policies used in other counties, we came up with four government controls: provide subsidy to families, increase police control in the community, invest in small to medium businesses, and invest in educational programs for juveniles. However, we are not sure which is the most effective control for our client's county since the same government control may have various effects in different counties.

Therefore, we decide to develop an agent-based simulation to explore the effects of different government controls on juvenile delinquency rate, therefore allow us to find the most effective government policy our client's county. We think an agent-based model is particularly suitable in this case because it takes human interaction and adaptive learning into consideration, which is a more accurate simulation of the real life situation. The independent variable in our simulation is the four government controls we came up with. These government control options will have different effects on a juvenile's personal stress, attachment to parents, exposure to

delinquent peers, and other factors that will influence one's decision of becoming delinquent or not. Therefore, the dependent variable is individual's delinquency. We will calculate the annual crime rate of the community subsequent to government policy to evaluate the effectiveness of the government policy.

Our agent-based model uses Agnew's book *Juvenile Delinquency: Causes and Control* as the major theoretical support. We also studied academic journals extensively when selecting our options, variables, and attributes. Our proposed four government options are designed to address the important aspects related to juvenile delinquency. The attributes of individual agents are selected based on the four major widely accepted theories explaining delinquent behaviors in sociology: strain theory, social learning theory, control theory and labeling theory. The attributes reflect these theories to different extend. The dynamics are based on assumption that different government options would influence various variables contributing to crime, and these variables would further affect the different attributes of individuals. A juvenile would commit delinquent behaviors when the sum of his or her attributes exceeds a certain amount.

We will run the model over times to test different government controls in order to help our client to find out the most effective control to reduce the juvenile delinquent rate and create a better community.

2. Method

Our model aims to find the best investment option for government in order to reducing juvenile delinquency according by using the theories from sociology. Users can allocation money on four options, which are the independent variables: proportion-of-family-subsidy, proportion-of-police-control, proportion-of-small-medium-business, and proportion-of-educational-programs. Each option has different effect on community status, which are dependent variables: direct-control-parents, direct-control-police, community-unemployment, community-norm, domestic-violence-rate, school-violence, school-involvement, government-total-income, government-total-income, business index, the number of crimes, quarterly family income, quarterly crime rate and quarterly unemployment rate. The community status then will affect the attributes of agents. Each agent has a score to measure its delinquent potential, and it shown as different colors. Darker blue means higher level of crime potential. Red means that agent is delinquent. White means that agent has zero potential of crime. Our simulation is a discrete time simulation and has total 40 ticks, means counts 10 years and one tick means one quarter. Users can also choose different investment method, community-attitude, and additional funding. By selecting the allocating the investment options, users can use the total number of crimes, which is cumulative, and quarterly number of crimes to see whether the option is effective or not.

We use BehaviorSpace to run the simulation 100 times for each different government options in order to find the most efficient investment method for the government. There are five options: put more investment proportion for the family subsidy, put more investment proportion on police control, put more investment proportion on education, put more proportion on business, and have a balanced investment allocation. Each options run 100 times, thus have total 500 replications. The specific tables will be shown in the Results section.

Pseudo Code:

1. A population is defined as 196 in a 14*14 patch. Each patch means one juvenile. Initially, all the agents are randomly assigned by blue (non-delinquent with delinquency potential, darker blue means higher potential), white (non-delinquent without delinquency potential), and red (delinquent). A juvenile 's deliquent likelihood represents the possibility of him commiting a juvenile deliquent behavior.

2. The user changes the proportion of four different investment channels on the Interface: family subsidy, police control, small-medium business and educational programs. The sum of the porprotations of the four options should be 1, and it will show up on the "Total Proportion" monitor.

3. After setting up everything, the observor can use "step" or "go" to run the simulation. "step" means that time advances 3 months, namely a quarter. "go" means that the time will continously advance till it reaches 40 (10 years).

4. The inital base numbers are based on the normal distribution random, means the probability of getting the normal characteristics is the largest.

5. There is one first-iteration which affects all environmental factors and one patch-iteration which affects all agent attributions.
    5.1 first iteration: direct-control-parents, domestic-violence-rate, school-involvement, direct-control-police, school-violence, community-unemployment and community-norm are factors that influence by the four investment four options.
    5.2 patch interation: personal-stress, exposure-to-delinquent-peers, family-income, personal-goal, attachment-to-parents, relations-with-peers, personal-belief, propensity-to-aggression and self-control are agent variables wil influence the delinquent-likelihood.

    5.3. For specific, the following variables will influence the deliquent score of one agent, and will have the following influence to each other:
    (+) means positive relationship between two factors, (-) means negative relationship between two factors
    1. Family Subsidy
    Influenced by: User Input

Influence:

      (+) Direct-control parents

      (-) Family Disruption

      (+) School involvement

2. Police Control

Influenced by: User Input

Influence:

      (+) Direct-control police

      (-) School Violence

3. Small-Medium Businesses

Influenced by: User Input

Influence:

      (+) Direct-control parents

      (-) Community Unemployment

4. Educational Programs

Influenced by: User Input

Influence:

      (+) Community Norms

      (-) School Violence

      (+) School Involvement

5. Direct Control – Parents

Influenced by: Family Subsidy, Small-Medium Business

Influence:

      (+) Personal Stress

      (-) Exposure to Delinquent Peers

6. Direct Control – Police

Influenced by: Police Control

Influence:

      (-) Exposure to Delinquent Peers

7. Community Unemployment

Influenced by: Small-Meduim Businesses

Influence:

      (+) Family Income

      (+) Personal Goal

8. Family Disruption

Influenced by: Family Subsidy

Influence:

      (-) Attachment to Parents

9. School Violence

Influenced by: Police Control, Educational Program
Influence:

       (+) Exposure to Delinquent Peers
       (-) Relations with Peers
       (+) Personal Stress

10. School Involvement
Influenced by: Family Subsidy, Educational Programs
Influence:

       (+) Relations with Peers

11. Community Crime Rate
Influenced by: Calculation
Influence: N/A

12. Community Norms:
Influenced by: Educational Program
Influence:

       (+) Personal Belief

13. Community Average Family Income
Influenced by:
Calculation = ΣFamily Income / Total Population Number
Influence: N/A

14. Personal Stress
Influenced by: Direct Control-Parents, School Violence
Influence:

      Delinquent Likelihood

15. Self-Control (genetic)
Influenced by: N/A
Influence:

      Delinquent Likelihood

16. Exposure to Delinquent Peers
Influenced by: Direct Control-Parent, Direct Control-Police, School Violence, School Involvement
Influence:

      Delinquent Likelihood

17. Attachment to Parents
Influenced by: Family Disruption
Influence:

      Delinquent Likelihood

18. Family Income
Influenced by: Community Unemployment, Family Subsidy

Influence:

       Deliquent Likehood

19. Personal Goal

Influenced by: Community Unemployment

Influence:

       Delinquent Likelihood

20. Relations with Peers

Influenced by: Scool Violence, School Involvement

Influence:

       Delinquent Likelihood

21. Personal Belief

Influenced by: Community Norm

Influence:

       Delinquent Likelihood

22. Delinquent Likelihood

Influenced by the sum of delinquent likelihoods of Personal Stress, Self-Control (genetic), Exposure to Delinquent Peers, Attachment to Parents, Family Income, Personal Goal, Relations with Peers and Personal Belief

       Influence: N/A

5.4 By getting one agent delinquent likelihood, we can set up the patch color. If a delinquent behavior is committed, the agent will change its color to red at this turn. The increasing delinquent likelihood will also cause darker blue.

Initialization:

The average population in United States county is 100,000. The average percentage of juveniles who are from 5 years old to 18 years old in a county is 17.5%. Therefore, the number of juveniles in a county is 17500. We reduce 17500 by 100 times, which means the number of agents (juveniles) in our model is 175. For convenience, we use 14*14 patch area, and we assume there are 196 juveniles in a community. The initial state is that each agent occupies one patch. Initially, all the agents are randomly assigned by blue (non-delinquent with delinquency potential, darker blue means higher potential), white (non-delinquent without delinquency potential), and red (delinquent). Initially, the four investment options are all zero, and the user should make the investment proportion. The number of crimes of is zero at the beginning. The government income is 10 initially. Investment method is smooth initially. The community-attitude is positive initially. There is no additional funding at the beginning. All the community status initial values are zero. There are eight attributes of one agent: personal-stress, exposure-to-delinquent-peers, family-income, personal-goal, attachment-to-parents, relations-with-peers, personal-belief, propensity-to-aggression and self-control. Each of the attributes has an initial base-value in the code, but those will not be shown to the users.

3. Results

Due to space constraints, you can find the full data on BehaviorSpace experiment document.

Results Summary:

BehaviorSpace results (NetLogo 5.0.4)
Juvenile Delinquency-Team 6.nlogo
Juvenile Deliquency Balance
12/09/2013 20:40:54:228 -0500

min-pxcor	max-pxcor	min-pycor	max-pycor
-7	7	-7	7

Government Policy				Others				Output	
proportion-of-police-control	proportion-of-small-medium-business	proportion-of-educational-programs	proportion-of-family-subsidy	additional-funding	community-attitude	investment-method	[step]	average number-of-crimes(10 years)	mean [family-income] of patches
0.3	0.2	0.3	0.2	0	"Positive"	"smooth"	40	351.45	13.48
1	0	0	0	0	"Positive"	"smooth"	40	244.45	11.94
0	1	0	0	0	"Positive"	"smooth"	40	530.54	19.08
0	0	1	0	0	"Positive"	"smooth"	40	354.30	11.84
0	0	0	1	0	"Positive"	"smooth"	40	415.30	11.75
0.7	0.1	0.1	0.1	0	"Positive"	"smooth"	40	298.13	12.76
0.1	0.7	0.1	0.1	0	"Positive"	"smooth"	40	446.96	16.28
0.1	0.1	0.7	0.1	0	"Positive"	"smooth"	40	363.74	12.69
0.1	0.1	0.1	0.7	0	"Positive"	"smooth"	40	408.23	12.26

4. Discussion

According to the Spacebehavior Results summary, we found that Police Control is the most efficient way to reducing delinquent rate. We controled the the same community attitude, investment method, additional funding. We changed the proportion on investmen accordingly. We want to find out the most efficient way to reducing the delinquent rate by having five control experiments. Each experiemt runs 100 times, and finally calculate the mean of the total number of crimes. We found out that when we put more money on police control, we have the least number of cirmes. The balaced allocation is also efficient, which has the second least number of crimes. Family subsidy control is least efficient since it will lead to the largest number of crimes among the five options.

5. Reference

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6. Appendix

a. Entity, State Variables and Scale

Our model has one main entity: juveniles. The model consists a population of 14*14 patches, each one occupies a patch. The patches bear no geographical meaning in regard to their physical locations. There are two types of entities: normal (represented by color blue) and the teenager who just commited a crime (juvenile deliquent behavior) at the current turn (represented by red color). The community is the environment in which juveniles reside.

The juvenile entity has 8 state variables: self-control, household income, attachment to parents, relations with peers, exposure to delinquent peers, personal stress, personal goal, and personal beliefs. More specifically, self-control, the ability to consider consequences before taking actions, is determined by genetic factors. Household income is the quaterly income of a family. Attachment to parents and relations with peers describe the emotional bonding between juveniles and their parents or friends. Exposure to delinquent peers reflects the likelihood that a juvenile learn delinquent behaviors from peer models. Personal stress is the level of strain as juveniles might cope their strain with delinquencies. Personal goal is the ability to achieve their goals and personal beliefs are their general attitudes towards delinquency. The environment community has 3 state variables: crime rate, community norm towards delinquency and average family income. The crime rate and average family income are calculated based on the attributes of juvenile entity.

In terms of temporal scale, our model is discrete. The unit of time is one month. Furthermore, there is no spatial scale because the entity is stationary.

b. Interface Design

There are four independent variables: Proportion-of-family-subsidy, Proportion-of-police-control, proportion-of-small-medium-business, and proportion-of-educational-programs. The user can allocate different proportions on those four options. The total proportion in the monitor should sum up to 1, and the user can use it to see whether their total proportion is 1 or not at Total Proportion. We are investigating the change of crimes in 10 years, thus we have 40 quarters in the plots.

The monitor called Number of crimes is used to count the cumulative number of crimes. The monitor called Government Income is used to shown the government income for total 10 years. Users can change the government income by changing additional funding.

Investment-method means how the government puts the money duirng a certain time period. Aggresive means the government puts great amount of money during in the early years of the whole time. Smooth means the government allocaties money smoothly duiring the whole time. Delayed means the government puts great amount of money during in the late years of the whole time.

The plot named Quarterly Number of crimes is used to show the cumulative number of crimes in a quarter during 10 years. Users can also know the crime rate by telling from the slope of the curve.

The plot named Quarterly Family is used to show the trend of household income quarterly. We can tell from the plot whether the household income will increase by the decrease of crime rate.

The last plot is quarterly unemployment rate, which is calculated by the unemployment people divided by the total population. We can tell from the plot whether the unemployment rate will decrease by the decrease of crime rate.

The monitors that are under community status show the score of each variable. The maximum score is 100 and mimium is 0.
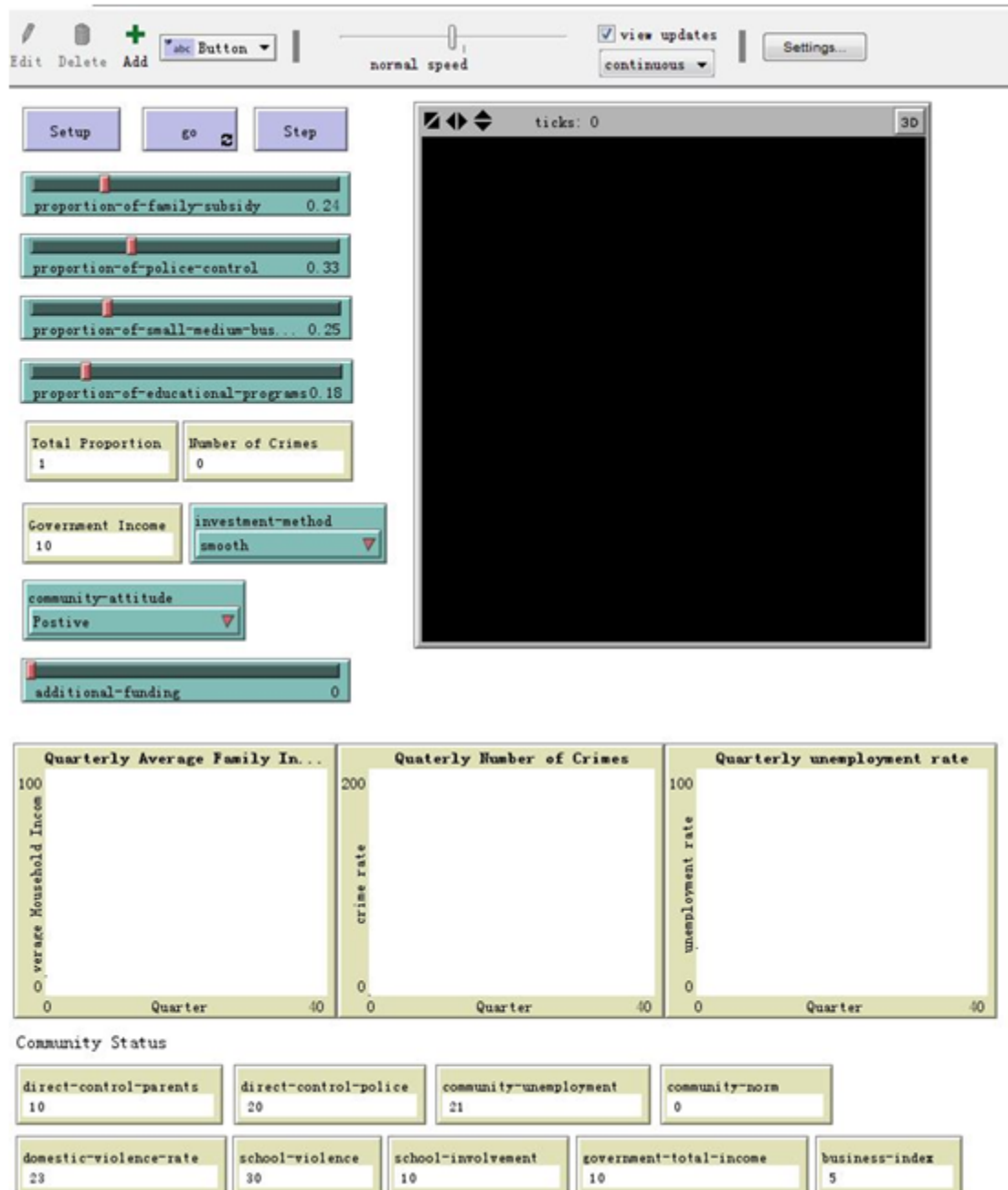
c. Process Overview and Schedule

Time is modeled as discrete time steps. Each time step represents an iteration. At each step, an amount of investment goes into the system, distributed proportionally to the parameters set at the interface.

Our model contains three groups: options, environment variables and agent attributes. Attributes are variables that reside with an entity, and do not contain any procedure that might alter other attributes. Variables are very similar to procedures, they may or may not contain a specific value, but they will affect the attributes (state-variables) on each agent. Variables are by their nature, intermediate instruments used to calculate attributes.

Factors in groups will either influence or be influenced by other factors.

I. Options – first group
       a. Family Subsidy
       b. Police Control
       c. Small-Medium Businesses
       d. Educational Programs
II. Environment Variables – second group
       a. Economic Deprivation
       b. Direct Control – Parents
       c. Direct Control – Police
       d. Community Unemployment
       e. Family Disruption
       f. School Violence
       g. School Involvement
III. Agent Attributes – third group
       a. Personal Stress
       b. Self-Control (genetic)
       c. Exposure to Delinquent Peers
       d. Attachment to Parents
       e. Family Income
       f. Personal Goal
       g. Relations with Peers
       h. Personal Belief

Explaination of the influence:

For specific, when government chooses to increase funds on small-medium businesses, it will decrease direct control from parents because parents have jobs so that they do

not have much time to control their children. Increasing small-medium businesses will reduce family disruption and community unemployment. The increase of job opportunities will increase household income and make it easier to achcieve personal goals. The decrease of direct control from parents will increase their children's exposure to delinquent peers. Also, juvenilles are under less pressure when their parents reduce their control on their children. The decrease of family disruption will increase juveniles attachment to parents.

When government chooses to increase funds on educational programs, it will reduce school violence becasue schools will educate students so that students will be less likely to be violent. When the funds on education increases, more and more students are able to get into schools and it will increase school involvement. The decrease of school violence will decrease the exposure to delinquent peers but increase the relationship with peers. By increaing school involvement, the relationship with peers will become better and it becomes easier to reach personal goals.

When government allocates funds to each family as subsidy, economic deprivation and family disruption will decrease. When family gets subsidy from government, the direct control from parents to juvenilles will decrease because parents do not need to worry to find a job immediately or work very hard, but they can have more time to care their children.

When government increases police control funds, the direct control from police will also increase. Thus the exposure to delinquent juvenilles will decrease. When police control increases, school violence will decrease.

Community also has its own attributes: average family income and community crime rate. The community crime rate is calculated quartely. It will turn to zero and get recalculated (cumulatively) for each year. The goal of this model is to reduce the crime rate.

d. Design Concepts

Emergence:
The changes in environment either lead to delinquent behaviors or non-delinquent behaviors depending on agent's state variables. The model allows us to study the effect of external environment change in individual attributes, which would affect an agent's decision of becoming delinquent or not. Thus, the model helps us to discover the most effective policy to control the overall delinquency rate in a poor community, which has relatively high delinquency rate.
Adaptation:

There are no adaptation mechanisms in the models. There is no geographical significance between agents; therefore, there is no interaction between neighbor agents. The decision of an individual agent is determined by the sum of its attributes, i.e. the delinquency score.

Objective:

There are no specific objectives for the agents to obtain. Agents do not have a specific goal that they deliberately aim to achieve. We only want to see how the attributes of agents respond to changes in external variables.

Learning:

Normally the probability of an agent committing a juvenile delinquent is the delinquency score divided by 100. In some sociological theories, especially labeling theory, people are more prone to commit crimes once others label them as "delinquent". The number 100 will go down logarithmically. It will slowly return to 100 if they haven't committed a behavior for a fixed amount of time.

Prediction:

An agent's prediction of its future conditions, either environmental or internal, will affect its present decision. This prediction mechanism specifically relates to the "personal goal" attribute of an agent. When an agent predicts that it will be hard for him or her to achieve a specific goal in the future (for example, have $200 next week), that agent is more likely to commit delinquent acts (for example, theft) to achieve his or her goal. Therefore, prediction will affect an agent's attributes.

Sensing:

There are no sensing components in the model because there is no need for agents to perceive their state variables. There is no social network for agents to sense each other.

Interaction:

Individual agents interact with each other mainly through the attribute "exposure to delinquent peers." When an agent has a high number of delinquent neighbors, the exposure to delinquent peers is therefore high. This would increase that agent's likelihood of making delinquent decisions. It is a direct interaction.

Stochasticity:

There are nine attributes of one agent: Household Income, Personal Goals, Exposure to Delinquent Peers, Personal Stress, Attachment to Parents, Relationships with Peers, Personal Belief, Self-Control. Household income is a random whole number in a range from 8,750 to 10,500 since the quarterly median household income in a relatively poor community is $40,910 (U.S. Census Bureau). Exposure to Delinquent Peers is a whole random number between 0 and

30 since the juvenile delinquency rate is 30% (U.S Department of Justice). Self-Control is a random number between 20 and 80. All other attributes are randomly assigned the value from 0 to 100.

Collectives:

There are no collectives in the model. Because there is no network in our simulation, it is not particularly meaningful to put agents with the same culture together.

Observation:

In the model interface, there is a graph with 196 (14*14) agents. Their display color is either red or blue. Red indicates the agent is committing a delinquency, while blue indicates the agent is in a normal state. An agent will turn back to blue after committing the crime and an agent could commit multiple number of crimes in a year. The crime rate is measured by the total number of crimes in the community. Therefore, graph in the interface would record each crime and plot the number of crimes in a year as output. The graph would reset to zero at the beginning of the next year. In this way we could compare the crime rates to see the effect of our government policies.