APPLICATION OF AGENT-BASED SIMULATION TO POLICY APPRAISAL IN THE CRIMINAL JUSTICE SYSTEM IN ENGLAND AND WALES

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ABSTRACT

This paper describes an agent-based approach for constructing a model of criminal justice system operations in England and Wales. The primary purpose of the model is to assess the impact of policy variants across the entire criminal justice system. Because of the structure of this system, three separate government departments interact and deliver services. Decisions in one area of the criminal justice system can be crucial in determining what happens in another area. Our purpose was twofold. First, we needed to contribute to the Treasury's spending review by working with different groups in criminal justice agencies to reach a consensus on how things actually occur (i.e., linking behavior and actions of one group with another and with resources). Second, we needed to produce a model of the entire criminal justice system that would provide insights into questions related to capacity, case flow, and costs. We also needed to model the ways in which individuals go through the system. The result is a hybrid model that combines a simple system dynamics approach with an agent-based model. The distinctive approach used in this work integrated modeling with practical ways of enabling people to engage in strategic policymaking, while taking into account the complexities of the criminal justice system. The agent-based framework developed to meet these needs models the criminal justice system, provides the ability to assess policy across the system, and allows sharing of model output to improve cooperative efforts among departments.

Keywords: Agent-based modeling, criminal justice system, visualization, policy appraisal simulation

1 INTRODUCTION

This paper reports on an agent-based approach for constructing a model that shows the operations of the criminal justice system in England and Wales. The primary purpose of the model is to be able to assess the impact of policy variants across the entire justice system.

Because the model is designed to help people to think about what happens when things are changed in a deliberative manner, we provide some examples of policy changes for which the model is designed to provide help. We also discuss a visualization that represents what the model can do for different policy views. With a view of "model as icon for change," the reality of the visualization is not as important as how it looks.

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Section 2 describes the context for the project — the structure of criminal justice in England and Wales. Section 3 discusses the purpose of the project, which goes beyond the mere construction of a model. Construction of the model included at least two aspects of interest: the way in which the problem was approached and the physical representation of some kind of solution, which we define as the model. These aspects are discussed in Sections 4 and 5. Section 6 provides concluding remarks.

2 CONTEXT

The criminal justice system in England and Wales is delivered by diverse government bodies; the same is true in many other countries. In England and Wales, these are not part of a single government department. Three departments are involved: the Home Office, which is by far the biggest financially and in terms of human resources; the Department of Constitutional Affairs; and the Crown Prosecution Service. Each of these departments has its own government minister, and in the case of the first two, has a range of responsibilities outside those considered in constructing a model of the criminal justice system. Thus, the Home Office is also responsible for immigration and for homeland security, whereas the Department of Constitutional Affairs also has the responsibility for civil and family law.

The Home Office criminal justice responsibilities include the Police Service, the Prison Service, and the Probation Service, but it is not a direct operational responsibility. Other agencies are responsible for delivering each service. Little direct financial accountability occurs (although all rely on central government funds), and there is only limited operational interference. Top-level targets are set for each service, but the utility of these is uncertain. Because operational control is divided across 42 areas of the country, determining what happens is a local matter.

The Department of Constitutional Affairs is responsible for both the courts and, via an executive agency, the provision of free criminal defense services (known as Legal Aid). The courts are divided between lower and higher courts: the former are called magistrates' courts and deal with lesser offenses; the latter are called the Crown Court and generally deal with more serious cases.

The Crown Prosecution Service is responsible for prosecuting criminal cases. It is the least complex of these bodies.

The functionality of the criminal justice system depends crucially on the way in which each of these bodies delivers services and on the interactions among them. Each part of the system has thousands of individual agents who act according to sets of rules. Some rules are fairly prescriptive, and others are rules of thumb, often undescribed.

Most of the funding for these service providers comes through the U.K. Treasury. Some other money flows through either local government sources or are private funds. For every government department, the U.K. Treasury has a system of spending reviews; these take place every two years and look three years ahead, therefore overlapping by one year.

Decisions in one area of the criminal justice system can be crucial in determining what happens in another. For example, how well the police functions may make the life of courts easier or more difficult, the workload of prisons more or less. This has been recognized by the

Treasury. Thus, in the 1998 spending review, the government undertook the first-ever review of the performance and management of the criminal justice system as a whole, cutting across all three government departments.

The 2002 spending review saw a cross-departmental review of the criminal justice system, which built on the work begun in 1998. However, the Treasury did not feel that the collective criminal justice system elements presented were sufficiently "joined up." Thus, for the 2004 spending review, the Treasury has required further development of the way in which all agencies bid, so that bids take into account what the other agencies are doing. The Treasury also requires that the bidding process be mediated through a model of the entire system. Our work is designed to address this need.

3 PURPOSE

Our primary task was to do something that would contribute successfully to the Treasury's spending review for 2004, and, beyond this, that could be used for assessment of future policy development across the whole of the criminal justice system. To achieve this goal, we worked at two levels. First, to establish a consensus about how things actually happen in the system, we worked with groups of people from different agencies in the criminal justice system. We gathered evidence of links between the behavior and actions of one person or group of people and another and through this process made arguments for the best use of resources. This new process was essentially about encouraging a change in the style of working of these core government agencies (see Pratt, et al. [1999] for a discussion of some ways of achieving this).

Second, we needed to produce a model of the entire criminal justice system that all actors in the system would recognize. To achieve this task, we worked with modelers and statisticians in the various government agencies and departments who were technical people interested in building better models. We acknowledge the extent of the contribution of the Criminal Justice Performance Directorate in this respect as well as various individuals in each of the departments and agencies of the criminal justice system. Our aim was to build on existing models of the system to produce an end-to-end computer model of the criminal justice system to provide insights, in particular into questions of capacity, case flow, and costs. This has the feel of a standard modeling problem, although ours was not a standard solution.

We needed to model how individuals — criminals or cases — move through the criminal justice system from the initial crime event to final disposition, culminating in receiving either a prison or a community sentence (including various forms of post-prison supervision), or in being released as a free member of the population. Moreover, these flows needed to be mapped against costed resources to meet Treasury requirements.

There was a third level of approach that we were only able to engage in tangentially. This involved the people doing the job, who are in fact those represented as agents in our model.

4 CONSTRUCTION OF THE MODEL

The project had two distinctive parts: (1) working with the people involved in making and delivering policy in the criminal justice system and (2) developing an adequate model of what the system does.

Working with people involved a range of activities:

- Determining user requirements through individual interviews and workshops, which culminated in the production of a user requirements report;

- Developing ways to assure the client that the model was really "them," again through interviews and workshops, and culminating in a test suites report; and

- Recording what the system does and why in terms of processes, activities, and resources, again through interviews and workshops, and resulting in the production of what was called a modeled processes report.

Each of these activities was also of fundamental importance in delivering a successful model, which comprised the second part of our task. The model developed was based on agent behaviors.

4.1 Inputs

To provide inputs to the model, we asked each agency to consider the following types of questions:

- What resources are used in providing services (i.e., what police and types, courts, custody suites, etc.)?

- What does each resource do, how does it makes choices, and are there different rules that can be selected in making those choices?

- What happens when capacity limits are threatened; how does prioritization take place?

- What are the costs of each resource, and how does this vary as decisions are made?

4.2 Outputs

The model represents the flow of activity through the criminal justice system, which can be analyzed in terms of, for example:

- Number of crimes reported,

- Number of cases tried in magistrates' courts,

- Cost of various types of resources, and

- Numbers waiting at different points in the system.

Each of these activities can be viewed at the minimal level of disaggregation (i.e., one agent doing one activity in one time slot), but each also can be aggregated over time, people, and activities to any required level.

5 AGENT-BASED HYBRID MODEL

We set out to produce a model that would engage people in the system. To meet this need, we adopted an agent-based approach. In the time allotted, however, it would not be possible to build an agent-based model for every part of the criminal justice system. The key question was, could we produce a model that would satisfy the needs of the client, while at the same time, take the client-system down the agent-based road by providing a model that the client could readily build on, and most important, would want to build on.

The result is a model that is a hybrid. It combines a simple system-dynamics model of flows through the criminal justice system — albeit with relatively complex interactions at each stage or node — with an agent-based model of individual agents that behave in ways that produce results that cannot be predicted from looking at the behavior of groups of the same agents.

Figure 1 represents the hybrid model concept. In some parts of the system, our model is more like process descriptions with high levels of agent homogeneity (superagents). In other parts, we have good descriptions of activities of individual agents with significant interaction among agents. Ultimately, the process and activity descriptions are mutually consistent (Bonabeau, 2002).

The model is structured in a way that allows the user to examine simple questions or more complex policy issues. "Simple" questions, however, are often only simple because the more complex issues they imply are ignored in that instance. Some typical policy issues are described in Box 1.

Increase the number of police by 10,000 (currently 130,000). Determine the impact on the system.

The impact depends on what activities the new police choose to do — more patrolling, more investigation, better case preparation, etc. All of these activities will have effects down the line for other service providers, and all will also affect how the agents themselves work.

Increase sentencing powers, for example, from 6 to 12 months, for certain offenses.

It may seem obvious that this policy will increase the prison population, but sentencers may choose to use the power differently. Moreover, defendants may react to longer sentences by appealing more or choosing a different court for the hearing. Any of these may result in different consequences from those that might have been supposed when the policy was first devised.
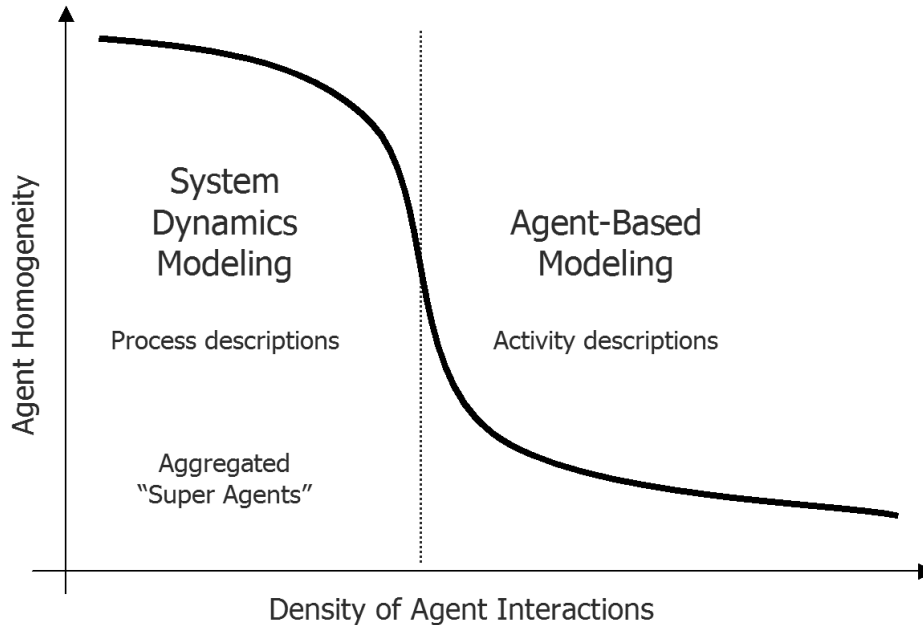
Box 1 Typical policy issues

System
Dynamics
Modeling

Agent-Based
Modeling

Process descriptions

Activity descriptions

Aggregated
"Super Agents"

Agent Homogeneity

Density of Agent Interactions

FIGURE 1 Hybrid modeling: process and activity-based descriptions

6 CONCLUDING REMARKS

At the end of the project, we have delivered an agent-based framework with the potential to model the impact of government policy on the criminal justice system. In addition to developing the model, we delivered the free-standing policy "tools" listed below. Each tool enables a practical application of systemwide thinking.

Thus, as part of the creation of the model we:

- Set up and facilitated a group known as the Spending Review 2004 Group, which helped to give ownership across government departments.

- Supported and developed the role of the Project Steering Group, which spanned agencies across the whole system.

- Developed a template for systemwide policy formulation called the Systemic Impact Statement.

- Offered a high-impact demonstration of flows across the system through computer visualization developed with the model, which is especially useful for nontechnical policy people. Box 2 provides further discussion of our use of visualization.

Another key aspect for the client was that all government departments and constituent agencies were signed up to the outcomes of the project. We interpreted this as meaning that each player

had to be involved in the development of the model, and the method of working. This was certainly achieved.

7 REFERENCES

Bonabeau, E., 2002, "Agent-based Modeling: Methods and Techniques for Simulating Human Systems," *Proceedings of the National Academy of Sciences of the United States of America* **99** Suppl. 3, 7280–7287.

Pratt J., P. Gordon, and D. Plamping, 1999, *Working Whole Systems*, London: Kings Fund.

We felt it was important to provide a visualization of the system that a wide range of users could relate to — to reach beyond those with a technical interest in the model to those who determine policy, such as high-level public servants and politicians.

Our use of visualization also allows the different service providers to see themselves as integral parts of a large whole. In a way, the visualization comes to represent the model as icon: it is almost as if people have something that they can touch while making their decisions.

This diagram shows a screen capture from the visualization. Our aim is for users to become more aware of the system and its parts, at the same time they see the size of flows along edges between nodes (e.g., the proportion of capacity used, timeliness between two nodes, or costs of providing services at each node.
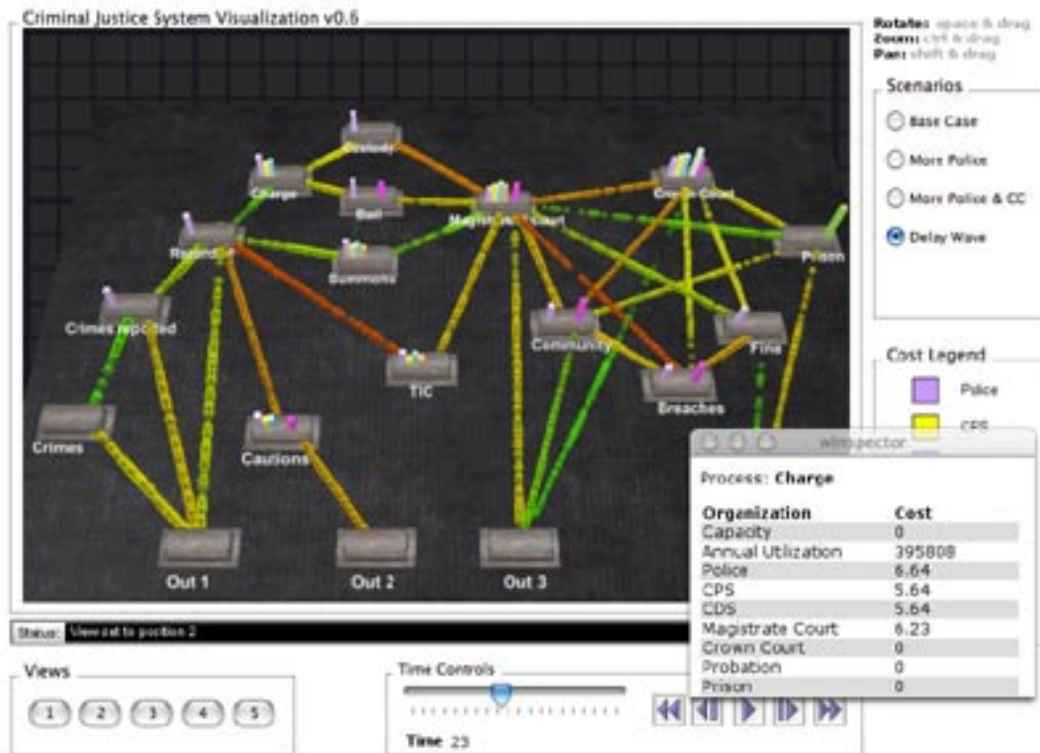
The visualization is decoupled from the model where the visualization reads the log files produced by the model. This approach allows us to easily switch between different scenarios produced by multiple-scenario runs. A second benefit is that it allows us to do early rapid prototyping to establish the scope of the project while the model is being constructed. We are able to use the same visualization for outputs of "scratch-pad" throw-away prototypes in various programming languages, then plug-in the actual model data when available. A third benefit to this approach, which cannot be overstressed, is the ability to more rapidly diffuse the model and its insights throughout the organization (because visualization with log files involves a much smaller memory footprint than deploying the model and all of its dependencies). The above benefits notwithstanding, one disadvantage of having a decoupled view is the inability to modify model parameters on the fly for interactive exploration by the user.

Box 2 Visualizing the system