Drug Policy Modelling Program

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Complexity sciences – exploring the complexity of heroin use in Melbourne

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Rationale

Complexity Theory is a loose cluster of theories and methodologies aimed at understanding the properties of complex adaptive systems. Complex adaptive systems (CAS) are ones characterised by: emergence; path dependency: non state equilibrium; and adaptation. The heroin drug market fits these characteristics nicely. The tools we have available to understand and model such CAS include Multi-Agent Systems, Dynamical Systems, and Network Theory. Scientists using Multi-Agent Systems tend to focus on the individual components interacting within a given system. This is a purely bottom-up approach where representations of the individual components – the agents – display a large autonomy of action. Hence, system-level behaviours and patterns emerge from a multitude of local interactions. Scientists using Dynamical Systems tend to focus on the flows of information, mass and energy within a given system. Practically, modellers describe systems as a set of modules or compartments (stocks) interlinked by flows and controls. Scientists using Network Theory tend to focus on the structure of interactions between individual components of a system.

The Complexity Theory group considered the advantages and limitations of using these approaches for DPMP. Two key issues shaped the boundaries and content of the present project: finding a case study that would contain – a priori – as much complexity as possible and would provide the information needed to build a consistent model; and fitting into the actual structure of the DPMP project in order to interact efficiently with relevant experts and to avoid undesirable overlapping with other on-going research.

Dynamical Systems were already being explored within the epidemiology team. Looking at the Australian illicit drug markets through a cross-scale approach, it seemed that urban districts constituting a 'drug scene' involved most of the actors (with exception of importing syndicates and production cartels) while displaying a maximal complexity. We chose the multi-agent system (rather than network theory) because most of the potential agents in the system were clearly identified but various aspects of their interdependent links were ill-defined. In addition, the high level of transdisciplinarity that was needed advocated for an intuitive modelling approach.

Approach

The model was created with the Cormas platform (Bousquet et al., 1998), developed from the VisualWorks commercial software. The transdisciplinary expert panel involved: P. Perez (design), A. Dray (modelling), A. Ritter (psychology), P. Dietze (epidemiology), T. Moore (economics), and L. Mazerolles (criminology).

The features of the agent-based model, called SimDrug, include the spatial environment, time scale, and social agents. Briefly, the spatial scale was an archetypal and over simplistic representation of Melbourne's CBD based on a regular 50*50 square mesh. Each cell - elementary spatial unit - corresponds to a *street block*. A *suburb* is defined as an aggregation of neighboring cells. Five suburbs were created with different sizes and shapes. Each time step is one day (24 hours). We have taken 1998-2002 as the reference period. In terms of validation, this time bracket gives us the opportunity to test the robustness of the model by comparing a series of micro (agent level) and macro (system level) indicators with corresponding observed data. The model must be able to consistently reproduce pre-drought, crisis, and post-drought dynamics of the system.

SimDrug includes different types of social agents: *users*, *dealers*, *wholesalers*, *police constables*, and *outreach workers*. Each type represents a minimum set of characteristics and dynamics that allows the whole artificial population to display most of the

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properties observed in real societies. The transdisciplinary work plays a paramount role in defining a consensual set of simplified rules for the corresponding agent to 'behave' realistically.

We chose to implement an open system that sustains a constant number of *users*, *dealers*, and *wholesalers* (*constables* and *outreach workers* remain the same). Estimations for Melbourne give a range of 30,000 to 35,000 drug users considered as regular addicts. In order to keep computing time into reasonable limits, we created a 1/10th model of the reality: 3,000 *users* are created in SimDrug. They are randomly located on the grid at the beginning of the simulation.

Key findings

Once the program was completed, various sensitivity analyses were conducted, testing the output from the model against validation data from the relevant time period. The variables used in the sensitivity analyses included: overdose rates, treatment figures, crime and hot spots, dealers' cash and the ratio of user-dealers. Further sensitivity analyses were also run to test the degree of variability in the model if key parameters were changed (for example changing the number of police or outreach workers). The model has proved robust and stable.

The model is now at prototype stage. It will require further testing and then expansion to include lateral complexity, vertical complexity, emerging simplicity and strategic adaptive policy (meta-agent).

Implications

SimDrug has demonstrated the plausibility of using a multi-agent system model to describe the relationships between heroin users, dealers, their surroundings and the two interventions modelled (outreach workers and police). The model is robust. Policy makers will be able to use the model to determine potential scenarios as a result of their intervention. For example, the impact of doubling the police resources can be evaluated in the simulation. Further work is required to produce the model in a user-friendly format. Then it will be tested with policy makers as a tool to enhance their policy decision-making.

Recent developments in the field of Complexity Theory indicate that future research will increasingly involve cross-breeding methodologies. Thanks to the incremental flexibility and calculation capacities of the new generation of computers, coupling Multi-Agent Systems with Network Theory, or blending Dynamical Systems and Network Theory, are already being explored by pioneering research teams. Stage Two of DPMP provides the opportunity to pursue this groundbreaking work further.

Research Team

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