Adaptive policy for urban planning: operational models in support of planning policy.

Venue: Hardy Building Rm 101. Time: 1-2pm

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University of Cambridge
OUTLINE

1. The argument in favor of adaptive policy

2. Complexity theory: The right moment in time to link planning decision and urban models
   - Matching the key attributes of PPS-DSS with Dynamic Simulation and Planning Decisions (Policy Support)

3. ‘Wicked problems’ and the wrong “decision makers model

4. Key areas to address: Calibration, Validation, Randomness, uncertainty, data-mining

5. The examples of models: The SLEUTH model; The CVCA model; CCID model; The DG-ABC model

6. Concluding remarks
1. The argument in favor of adaptive policy
Cities and landscapes evolve - in time and space (across scales and along the same scale)

- The rational models of the 50-70s - systems theory or participative theory - they are both based on the ‘presumption of certainty’ - they provide one answer to the decision maker (static snapshot of time)

- Historical evolution is due to theory, practice, professional qualifications/numbers, computation, data constraints
The simplified reality of static world resulting from overlays of data is not enough.

Today is a result of complex physical and social interactions that have in account past events and future expectations.

Pure causation is not enough and cumulative effects, ‘carrying capacity’, self-organization, etc. play important roles.

 Complexity theory
What is complexity?
- In terms of representing various phenomena
  - A – yes/no
  - B – only complexity
    - (i.e. water convection cells
      - at the edge of “chaos”)
  - C – yes/no (non complex phenomena)

A and C can be dealt with other models, but CM can be very important
B can only be understood by using Complexity models

Why: because B represents a “transient reality” something that will become different
(the trajectory is not “linear” 1+2= might not be equal to a same reality (even if more/less intense))
Identification of complex behaviour for an element or phenomena through time

Identification of complex behaviour for multiple elements or variables through time and space
How a particular phase transition is deployed – the vortex of time

Simplified reality:
- Discrete elements
- With elements that constrain the function of the systems having their maximum impact to a transition at a particular time and space.
Nevertheless, with a particular moment in time that triggers entire system to a transition (“the vortexes of time”).
2- ‘Wicked problems’ and the wrong “decision makers model”

- Rittel and Webber’s 1973 conception of “wicked problems” to explain why conventional scientific approaches failed to solve problems of pluralistic urban societies.
- Try to confront (urban) social problems with the wrong tools because we have misunderstood the very nature of the problems. “wicked problems have no stopping rule,” and “wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions.

- The concept of certainly in an uncertain world
- The timing of Lee’s requiem and Rittel and Webber’s Wicked problems
3. Complexity theory: The right moment in time to link planning decision and urban models

- Mismatch between technology, theory, data of the 70s resulted in Lees’ “Requiem for large scale models”
- XXI century of Big Data, high computation capability, vast numbers of experts, more data-aware policy
CAs

(i) A grid or raster space – organised by cells which are the smallest units in that grid/space;

(ii) (ii) Cell States – cells must manifest adjacency or proximity. The state of a cell can change accordingly to transition rules, which are defined in terms of neighbourhood functions;

(iii) (iii) The neighbourhood and dependency of the state of any cell on the state and configuration of other cells in the neighbourhood of that cell;

(iv) (iv) Transition rules that are decision rules or transition functions of the CA model and can be deterministic or stochastic;

(v) (v) Sequences of time steps. When activated, the CA proceeds through a series of iterations

study of random complex CA came an understanding of its basic patterns: as they appear to fall into four qualitative classes, in what concerns one-dimension (1-D) CA evolution leads to: (i) a homogenous state; (ii) a set of separated simple stable or periodic structures; (iii) a chaotic pattern; (iv) complex localised structures, sometimes long-lived (Wolfram, 1984:5)
ABM-GAs are constituted of:

- \((i)\) agents that do not have the constraints of neighbourhood effects,
- \((ii)\) behavioural roles among agents and the environment itself, \((iii)\) independence from central command/control, but able to act if action at a distance is required,
- \((iv)\) states of agents tend to represent behavioural forms.

The most basic model environment of an ABM-GA will have a set of attributes per agent (or group of agents), (one) a set of decision trees and trigger points that will allow to set the context for a new movement (upgrade of the spatial/temporal environment) in time/space.
Starting the study of complex systems in Spatial Analysis ....

- Waldo Tobler in contact with Arthur Burks was exposed to Von Neumann’s works, and published ‘Cellular Geography’ (1979).

- At NCGIA-Santa Barbara, Helen Couclelis and Keith Clarke, published respectively ’Cellular Worlds’ (Couclelis, 1985) and develop the first fully operational and implementable CA (Clarke and Gaydos, 1998). While et. since the 1990’s focus in the ‘adaptive’ CA as a basis basis of integrated dynamic regional analysis (1997 )

- Michael Batty initially at NCGIA-Buffalo and afterwards at CASA-UCL, developed the theory and practice that culminated in the publication of the seminal books ’Fractal Cities’ (1994) and ‘Cities and complexity’ (2005). Recently, Wolfram’s book ‘A New Kind of Science’ (2002)

- ES = 3rd Generation (consolidation, reassemble, expansion, validation)
Operational Dynamic Urban Models
SLEUTH Urban Model

CVCA Environmental Model

Expert Inclusion ‘people’s model’
2. SLEUTH
Identification/Quantification of the metrics that control the behavior of the system

Identification/Quantification of phase transitions

Confirmation of fractal dimension

AML

AMP

Urban growth

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3. CVCA Model

CVCA - CA - Environmental Model
<table>
<thead>
<tr>
<th>Transition Rules:</th>
<th>Number of pixels (pixels with a probability of change to urban)</th>
<th>Action step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Protective</td>
<td>0 but NN &gt; MNND</td>
<td>than add protective pixels around all outer patch and add protective pixels until arriving at closest neighbor</td>
</tr>
<tr>
<td>2. Defensive</td>
<td>&lt;=50% **</td>
<td>than add defensive pixels to all outer patch cell where transition cell exists</td>
</tr>
<tr>
<td>3. Offensive</td>
<td>&gt;50%</td>
<td>add offensive pixel to all outer patch cells and add offensive cells until nearest neighbor</td>
</tr>
<tr>
<td>4. Opportunistic</td>
<td>0 but NN = NNI</td>
<td>(and no transition cell nearby) than link to nearest neighbor</td>
</tr>
<tr>
<td>5. Grow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Desired network elements are identified and protected through planning policy and land use control in advance of negative landscape matrix changes.**

**Isolated core area in ‘non-supportive landscape matrix’ is subject to isolation from disturbance to corridors and to incremental reduction in size of the core area that can be protected through a new buffer zone.**

**Isolated core area is protected with a buffer zone and linked into a greenway network with corridors that are newly developed within a non-supportive landscape matrix context. The offensive strategy employs a range of tactics, including nature development, to achieve a desired landscape configuration.**

**Isolated core area is linked with an existing corridor, buffered, and anew supporting landscape matrix is developed. The opportunistic strategy takes advantage of unique circumstances that may only support some greenway uses, e.g. recreation.**

**Existing Landscape**
- Core
- Buffer Zone
- Corridor

**Goal or Result**
- Supporting Landscape
- Non-Supporting Landscape Matrix

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<table>
<thead>
<tr>
<th>Metric - AML</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edges</td>
<td>35171</td>
</tr>
<tr>
<td>Area</td>
<td>106460</td>
</tr>
<tr>
<td>Num Clusters</td>
<td>1134</td>
</tr>
<tr>
<td>MCS</td>
<td>93</td>
</tr>
<tr>
<td>MPS</td>
<td>577</td>
</tr>
<tr>
<td>LSI</td>
<td>9.9</td>
</tr>
<tr>
<td>MNND</td>
<td>1.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric - AMP</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edges</td>
<td>14964</td>
</tr>
<tr>
<td>Area</td>
<td>24204</td>
</tr>
<tr>
<td>Num Clusters</td>
<td>708</td>
</tr>
<tr>
<td>MCS</td>
<td>34</td>
</tr>
<tr>
<td>MPS</td>
<td>275</td>
</tr>
<tr>
<td>LSI</td>
<td>7.7</td>
</tr>
<tr>
<td>MNND</td>
<td>1.5</td>
</tr>
</tbody>
</table>
CVCA Simulation
Protective cells

Defensive corridor

Promoting big patches, by avoiding divide on big patch in to two
4. The People’s model
TWO MAP DRAWINGS RESULTING FROM THE WORKSHOP’S AFTERNOON
<table>
<thead>
<tr>
<th>Strengths</th>
<th>Votes %</th>
<th>Weakness</th>
<th>votes %</th>
<th>Opportunities</th>
<th>Votes %</th>
<th>Threats</th>
<th>votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport system (road network, airport, harbor)</td>
<td>19.5</td>
<td>Mobility, accessibility and transport</td>
<td>32.6</td>
<td>Improve transportation system</td>
<td>17.6</td>
<td>Uncontrolled urban sprawl</td>
<td>29.9</td>
</tr>
<tr>
<td>Tourism and world heritage (Lisbon and Porto)</td>
<td>17.8</td>
<td>Lack of urban quality</td>
<td>17.0</td>
<td>Urban renewal</td>
<td>15.7</td>
<td>Natural risks (e.g. coastal, flooding, earthquake)</td>
<td>16.4</td>
</tr>
<tr>
<td>Capital city</td>
<td>13.0</td>
<td>Uncontrolled urban sprawl</td>
<td>11.3</td>
<td>Cultural tourism/events</td>
<td>11.8</td>
<td>Urban violence and drugs</td>
<td>14.2</td>
</tr>
</tbody>
</table>

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1. The image of the city

- The image of a city-region
- Identification/quantification
- Urban forms (existent /possible)

- “same future” – different simulations
7. DG-ABC MODEL

Concept model of DG-ABC model

<table>
<thead>
<tr>
<th>Dynamics capturing</th>
<th>Intelligent agents</th>
<th>Cellular automata</th>
<th>TPB model</th>
<th>Genetic algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>a-spatial dynamics</td>
<td>spatial dynamics</td>
<td>behavioural regulations</td>
<td>behavioural optimizations</td>
<td></td>
</tr>
<tr>
<td>Factors oriented</td>
<td>social-economic influences</td>
<td>infrastructures/ecosystems</td>
<td>behaviours of agents</td>
<td>behaviours of agents</td>
</tr>
<tr>
<td>Level</td>
<td>individual</td>
<td>individual</td>
<td>individual level</td>
<td>high level</td>
</tr>
<tr>
<td>changes</td>
<td>alter behaviours by GA and themselves</td>
<td>neighbourhoods navigation</td>
<td>N/A</td>
<td>evolution by themselves</td>
</tr>
<tr>
<td>Data requirement</td>
<td>social-economics/policies quantifying</td>
<td>GIS data</td>
<td>agent's beliefs/profile information</td>
<td>strategies/options</td>
</tr>
</tbody>
</table>

Integrated model
3.2 DG-ABC model

1. Model Environment
2. Heterogeneous agents
3. CA (SLEUTH)
4. Decision behaviors
5. Interactions
6. Synchronization

The key decision tables:
- The Resident agents’ utility table.
- The developer agents’ development application table.
- The government agent’s approving table.
- Synchronization decision table.

Source: Ning Wu and Elisabete A. Silva 2010a

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3.3 Theory of Planned Behavior

TpB model (Icek Ajzen 2006)

- **A**: the degree to which the performance of the behaviour is positively or negatively valued.
- **SN**: an agent’s perception of social normative pressures, or relevant others' beliefs that the agent should (not) perform such behaviour.
- **PBC**: an individual’s perceived ease or difficulty of performing the particular behaviour.
- **I**: an indication of a agent’s readiness to perform a given behaviour.

\[
A_i^a = A p_d^a \cdot W_p^i + A_{ct}^a \cdot W_{ct}^i
\]

\[
I = \begin{cases} 
SN_{i}^{a} = \sum_{j=1}^{n} (M_{ij} \cdot Inf_{ji}^{a}) / N_{i}^{i \text{ neighbor}} \\
\text{PBC}_{i}^{a} = \sum_{k=1}^{m} C_{i}^{a} \cdot P_{k}^{a}
\end{cases}
\]

\[
EI^a = a \cdot E_{\text{traffic}} + b \cdot E_{\text{environment}} + c \cdot E_{\text{convenience}} + \epsilon_{ij}
\]

\[
E_{\text{traffic}} = w_1 \cdot A \cdot e^{-B_{\text{road}}} + w_2 \cdot A \cdot e^{-B_{\text{highway}}} + w_3 \cdot A \cdot e^{-B_{\text{outside}}}
\]

\[
Be = W_1 \cdot I + W_2 \cdot AbC = W_1 \cdot I + W_2 \cdot EI
\]

\[
D = f(B) = \max \{Be^1, Be^2, Be^3 \ldots \ldots \ldots \ldots Be^n\}
\]
### Properties of government developer agents

<table>
<thead>
<tr>
<th>Government Agent</th>
<th>Consider factors</th>
<th>Influence Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master plan</td>
<td>Excluded area</td>
<td>Excluded areas</td>
</tr>
<tr>
<td></td>
<td>Infrastructure plan</td>
<td>Road growth</td>
</tr>
<tr>
<td></td>
<td>Developers attribute</td>
<td>trust probability</td>
</tr>
<tr>
<td></td>
<td>Residents’ interests</td>
<td>adjust probability</td>
</tr>
</tbody>
</table>

### Properties of resident agents

<table>
<thead>
<tr>
<th>Developer Agent</th>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand personal traits</td>
<td>Market location orientation</td>
<td>Low/middle/high</td>
</tr>
<tr>
<td></td>
<td>Customer orientation</td>
<td>Presented by</td>
</tr>
<tr>
<td></td>
<td>House price range</td>
<td>Land price range</td>
</tr>
<tr>
<td>Market attributes</td>
<td>Market share</td>
<td>Market Influence power</td>
</tr>
<tr>
<td></td>
<td>Credit record</td>
<td>successful applications rate</td>
</tr>
</tbody>
</table>

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Spatial synchronization in the model

Temporal synchronization in the model
- (a) run CA standby
- (b) run agents standby
- (c) run integrated model
- (d) real urban data
An Integrated Spatial Analysis Environment for Urban-Building Energy Analysis in Cities (I-UBEA)

- To track energy change
  - Energy change of London
  - Energy change per local authority / buildings

- To estimate and analyze Energy Usage Intensities (EUI)
  - EUI of Local Authorities
  - EUI of sub-categories of buildings

- To explain energy consumption
  - Explain how the distribution of land use influences energy consumption in local authorities and the entire city of London
  - Explain how the distribution of floor area influences energy consumption

- To evaluate energy performance
  - Evaluate energy performance of London while adapting different energy change policies.
  - Interactive Simulation Model for predicting of energy performance in the future on the basis of population change.

**FUNCTION OVERVIEW OF I-UBEA**

- **GIS Data Visualization & Data query in different spatial scales, for both polygon and point data**
- **Policy impact simulation and energy prediction (with population dynamic using statistics model)**
- **Explain energy consumption with attribute data by using Statistics Analysis**
- **Attribute Data**
- **Energy & EUI**
- **GIS Boundary Data**
- **I-UBEA**
- **Department of Engineering**
- **Department of Land Economy**
Energy scenario analysis (what-if analysis)

This method is more flexible compared to regression analysis because it is suitable for the situation where energy consumption data are unavailable in some spatial scales or some areas of a city.

1. **Baseline scenario**
   - The baseline scenario is based on prior knowledge on energy use intensity in terms of building types.
   - Three methods are provided:
     - benchmark values
     - median values
     - Monte Carlo method
   - Analysts may choose one or all these three methods based on data availability.

2. **Electrification**
   - This scenario is to explore how the total energy or carbon emissions would change if building sector would use electricity instead of gas for heating.

3. **Building type conversion**
   - This scenario investigates the change of building types on the energy consumption in cities.

4. **Energy efficient**
   - This scenario allows analysts studying the influences of change of energy use intensities for different building types.

Note: The benchmark values are based on low, typical, and high values (EUI) from previous literature.
Model function: Energy optimization

- **Data**: UKMap, floor area of London, Gas Energy consumption for each MSOA in London.

- Calculate EUI for MSOA and find polygon with best EUI.
- Calculate area percentage for all polygons.
- Pick best performing ratio and calculate mean ratio.
- Calculate difference to best performing ratio and difference to mean ratio, respectively, for compositional data.
- Calculate overall difference to best performing ratio and to mean ratio, respectively.

- **Part 1.** Display overall difference to best performing ratio with scaled color
- **Part 2.** Display overall difference to mean ratio with scaled color

**Note**: Each part of step 6 can be executed independently.
Result: Energy optimization based on building types at MSOA level in London

- To compute the overall difference of floor area percentage to best-performing area in terms of gas use intensity at London MSOA level.
- The overall differences of floor area percentage based on gas use intensity still presents the characteristics of spatial distribution to some extent, though not clustered as large area.
- Spatial distribution demonstrates that energy consumptions in an area are to some extent influenced by where the area is located in a city.
5. CI Agent Base Model

- variation in CI firms’ number & size
- demand for office
- interaction & feedback
- urban government
- compensation
- demand for CWs
- interaction & feedback
- expect. & feedback
- advocating, regulating & controlling
- land expropriation, urban regeneration
- compensation
- new housing estate
- existing housing estate
- demand for housing
- new housing estate
- existing housing estate
- to accept
- individual citizens
- to refuse
- to refuse
- existing housing estate
- new housing estate
- to accept
- individual citizens
- to refuse

- influence upon land-use type and citizens of neighbouring plots
- spatial structure of CIs firms
- locational determinants for CWs’ housing choosing
- spatial structure of CWs’ habitation
- determinants for CI firms’ location choosing
- variation in CWs population
- new policies for CI, CWs and land-use plan

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Agents and terms for negotiation

- Agents: 196 countries
  - Annex1 (42)
  - No Annex1 (149)
  - Others (5)
- Terms for negotiation
  - Technology trade
  - Carbon trade
  - GDP growth support
- Negotiation rules

Table 1: The three adoptable strategies and their influence on the two involved countries

<table>
<thead>
<tr>
<th></th>
<th>Carbon Sells</th>
<th>Technology Sells</th>
<th>GDP growth support</th>
</tr>
</thead>
<tbody>
<tr>
<td>A as sender</td>
<td>Technology (Carbon/GDP)</td>
<td>↑</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Extra Carbon emission</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>GDP growth rate</td>
<td>--</td>
<td>↑</td>
</tr>
<tr>
<td>B as receiver</td>
<td>Technology (Carbon/GDP)</td>
<td>--</td>
<td>↑</td>
</tr>
<tr>
<td></td>
<td>Extra Carbon emission</td>
<td>↑</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>GDP growth rate</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>
## Condition-action rules

### Table 2: The condition-action rules for each country

<table>
<thead>
<tr>
<th>Condition</th>
<th>Actions (Strategies)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP/capita &lt; Critical value</strong>&lt;br&gt;Not included in the Negotiation process, Focusing on GDP growth</td>
<td>1. Look for carbon sells&lt;br&gt;2. Look for GDP growth support&lt;br&gt;3. Quit technology application</td>
</tr>
<tr>
<td><strong>GDP/capita &gt;= Critical value</strong>&lt;br&gt;GDP-growth-rate &lt; Critical value&lt;br&gt;Carbon-emission/GDP &lt; critical value&lt;br&gt;Negotiation, aiming to lift GDP growth rate</td>
<td>1. Look for carbon sells&lt;br&gt;2. Look for GDP growth support&lt;br&gt;3. Renegotiate existing agreements aiming to promote GDP growth rate&lt;br&gt;4. Reduce technology application (in)</td>
</tr>
<tr>
<td><strong>Carbon-emission/GDP &gt;= critical value</strong>&lt;br&gt;Negotiation, to lift GDP growth, consider carbon reduction</td>
<td>1. Look for carbon sells&lt;br&gt;2. Look for GDP growth support&lt;br&gt;3. Reduce technology application aiming to promote GDP growth rate</td>
</tr>
<tr>
<td><strong>GDP-growth-rate &gt;= Critical value</strong>&lt;br&gt;Carbon-emission/GDP &lt; critical value&lt;br&gt;Negotiation, following current agreements and strategies</td>
<td>1. Keep carbon sells (in)&lt;br&gt;2. Keep GDP growth support (in)&lt;br&gt;3. Keep technology application (in)</td>
</tr>
<tr>
<td><strong>Carbon-emission/GDP &gt;= critical value</strong>&lt;br&gt;Negotiation, aiming to carbon reduction</td>
<td>1. Renegotiation carbon sells (in) aiming to reduce carbon&lt;br&gt;2. Renegotiate GDP growth support (in) aiming to reduce carbon&lt;br&gt;3. Look for technology application (in)</td>
</tr>
</tbody>
</table>
Some Papers


2004 The DNA of our Regions: artificial intelligence in regional planning. Futures, 36(10):1077-1094. – ISSN: 0016-3287


0965-4313
Some book chapters


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LISA Lab

www.landecon.cam.ac.uk/research/lisa

New Book: "The Routledge Handbook of Planning Research Methods"
http://www.routledge.com/books/details/9780415727952/