

## Empirical Modelling to inform the delivery of UK government policy

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## About me

- o BSc Computer and Business Studies (Warwick, 2004)
- o MSc in Computer Science by Research (Warwick, 2007) "Uncovering Empirical Modelling"
- o Consultant at Databuild since October 2005
- o Still maintain an interest in:
  - Empirical Modelling
  - Philosophy of computing
  - The development, deployment and strategic use of information systems



## About Databuild

*Databuild works for organisations that are trying to have a positive impact on society*

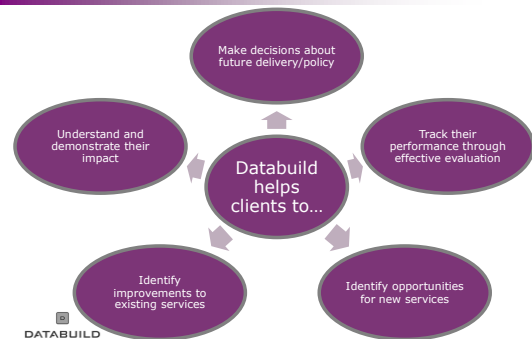


*We aim to be chosen by governments and other organisations to help them achieve their policy objectives more effectively*



Research-based consultancy

## How we help our clients



## Why is Databuild interested in modelling?

- o Ultimately, we want to help our clients make better use of evidence and understanding to inform their activities
- o We are excited about the prospect of models being used by policy makers / those involved in delivering government funded projects/programmes
- o We recognise that models can support the kinds of observation and experiment that lead to improved knowledge and understanding
- o We believe effective modelling can support better decision making



## Lecture outline

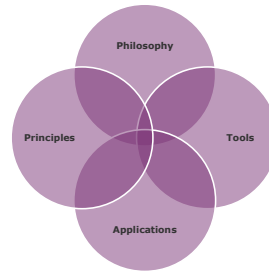
- o My construal of Empirical Modelling
- o Overview of the impact model we have developed for Defra / WRAP
  - Context
  - Objectives and method
  - Demonstration of the model
  - Discussion of what the model enables
- o We would talk about our work as empirical modelling, but to what extent can it be described as Empirical Modelling?
- o Concluding remarks
- o Opportunity for questions



## My construal of Empirical Modelling

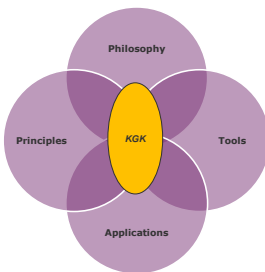
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## Empirical Modelling



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## Where the work I undertook in my MSc fits in...

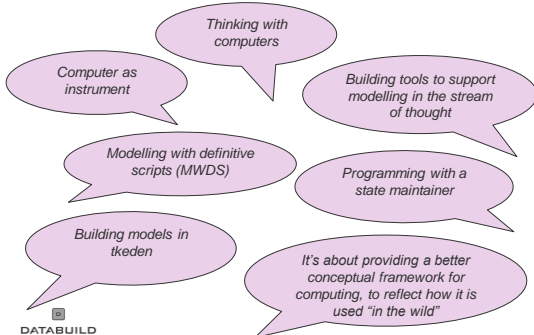


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## What does EM mean to you?

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## Myriad perspectives on / reactions to EM...



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## Foundations for my current perspective...

*"Computers turn out in the end to be rather like cars; objects of inestimable social and political and economic and personal importance, but not in and of themselves, qua themselves, the focus of enduring scientific or intellectual inquiry."*

*Rather, what computers are, I now believe – and what the considerable and impressive body of practice associated with them amounts to – is neither more nor less than the full fledged social construction and development of intentional artefacts."*

**Brian Cantwell Smith. The foundations of computing. In Computationalism: new directions, Matthias Scheutz, editor, MIT Press, 2002.**

*"Although efficient access to data is an essential function of computing, the greater potential is for computers as modelling machines, not knowledge jukeboxes. To think of them as only the latter is profoundly to misunderstand human knowledge."*

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### Empirical Modelling


- o A way of thinking about:
  - **The nature of human knowledge** – how it develops and evolves through observation and experiment
  - **The semantics of computer based artefacts** – shifting away from the view of semantics as the abstract behaviour that a program implements
  - **The role computers can play in the world** – they can be more than mere knowledge jukeboxes / number crunchers
- o EM calls computer scientists to:
  - Challenge the traditional construal of computing
  - Design tools that better support the development of *intentional* artefacts
  - Take the discipline into a new age of discourse

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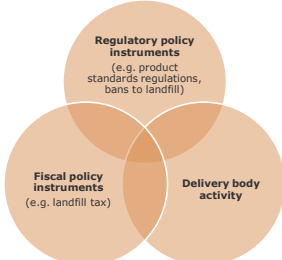
### Defra / WRAP impact model

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### Department for Environment Food and Rural Affairs



Defra has a policy objective to achieve sustainable, resource efficient patterns of consumption and production in the UK...



**Regulatory policy instruments**  
(e.g. product standards regulations, bans to landfill)



**Fiscal policy instruments**  
(e.g. landfill tax)

**Delivery body activity**

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### Delivery body activity

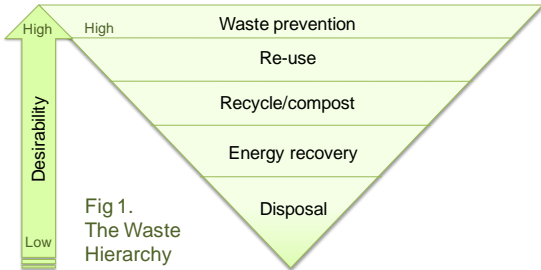
Defra provides funding to the Waste and Resources Action Programme (WRAP) to undertake activities that encourage or enable UK businesses to be more resource efficient...

...to use natural resources in the most effective way, as many times as possible, while minimising the impact of their use on the environment

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### The waste hierarchy



**High** High

Waste prevention

Re-use

Recycle/compost

Energy recovery

**Low** Disposal

Desirability

Fig 1. The Waste Hierarchy

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### What does WRAP do?

- o WRAP's priorities during the current business plan:
  - Minimising resource use in products and buildings
  - Diverting priority materials from landfill
- o WRAP's priorities:
  - Prevent food and drink waste
  - Increase the resource efficiency of products
  - Increase the resource efficiency of construction and refurbishment projects
  - Improve the collection of materials for recycling and reuse
  - Help SMEs to become more resource efficient
  - Recycling organic waste and recovering energy
  - Increasing the reuse and recycling of priority products

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## WRAP's goals:

7 million tonnes less carbon dioxide equivalent emitted a year

3 million tonnes less biodegradable waste going to landfill a year

£1.9 billion saved by consumers, businesses and the public sector a year

£130 million growth in the resource management sector a year

3 million tonnes less primary resources used a year

2 million tonnes less waste produced a year

## Where we fit in...

- o In 2008 there were seven resource efficiency delivery bodies:



- o Decision made to consolidate delivery – WRAP
- o Databuild commissioned to review evaluation methodologies and make recommendations to the new delivery body

## Key objectives of the project

- o To develop a consistent framework for evaluating the impact of the resource efficiency delivery activities
- o To estimate the lifetime impacts of activity undertaken in a given year
- o To perform an assessment of the value for money of individual activities to inform future policy and delivery

## Our solution

- o Impact model approach
- o Development in the spirit of EM:
  - Novel approach in this problem domain
  - Model has evolved as knowledge and understanding has developed
  - But also helps to shape knowledge and understanding
- o Developed using Excel:
  - Sufficiently flexible / sophisticated for our needs
  - In widespread use and doesn't require our clients to have any significant technical know-how
- o NB the primary goal is to:
  - Support the decision maker not automate the process
  - Provide a solution with efficacy not necessarily elegance / efficiency

## Model demonstration

*NB all figures presented are for illustration only as the actual results are confidential*

**Well that certainly looks like empirical modelling, but is it Empirical Modelling...?**

### What characterises Empirical Modelling?

**Construal, observation and experiment**

Model supports modeller in developing one or more *construals* of a referent and making meaning through observation/experiment

**An intentional artefact with meaningful state**

The state of the model is indivisibly linked to a meaningful state "in the world"

**Observables, dependency and agency**

The construal/referent can be described/thought about in terms of observables, dependency and agency

**Ease of embellishment**


The model is open to embellishment on the fly (e.g. in light of new evidence/understanding or experimentation/hypothesis testing)

**Minimal abstraction**

The model minimises/eliminates unnecessary abstraction from the real world referent


**Human interaction with computers**

Initial goal is not to produce a simulation or automated solution; it is to produce an artefact to support thinking




### Construals and the making of meaning

- Impact model supports modeller in building construal of referent situation in the world
- The model:
  - Embodies Databuild's current construal of the impact of WRAP's activities
  - Provides a means of connecting the available evidence in a way that is fully transparent to the 'user', enabling the construal to be communicated
  - Provides opportunity for:
    - Basic 'what if' scenario-based observation and experiment
    - More confident/competent users to embellish the model in light of new/additional evidence




### An intentional artefact with meaningful state

- The model is intentional in the sense that it has an "aboutness"
- Its state is *predominantly* experienced indivisibly from that of the referent; observables directly relate to observables in the world
- Spreadsheet reduces the referent, but is an artefact to be experienced, not simply 'used':
  - General interaction – "in the stream of thought"
    - Each redefinition results in a new state
    - New state experienced/interpreted as if it were that of the referent
  - Breakdown – modeller attends to the 'model' where immediately given connection in experience between the model/referent is broken



### Observables

Amount of money spent by Defra/WRAP on individual activities	Activities undertaken/planned by Defra/WRAP	% / number of businesses taking action following engagement with each activity
The nature of the action – material type, recycling/reuse	Impact of actions (e.g. material diverted from landfill)	How much money a business saves by, say, diverting material from landfill
The change in carbon dioxide equivalent emissions as a result of actions taken	The extent to which actions taken by businesses are supported/influenced by the activities	The extent to which actions taken by businesses are supported/influenced by multiple activities
... and many more...		



### Model structure and dependencies

What did WRAP do/how?

Activity data (e.g. number of events, number of attendees per event)

Number of beneficiaries taking action

Outcomes per beneficiary – one off and ongoing

What are the implications, e.g. in terms of CO<sub>2</sub>e?

Carbon dioxide equivalent outcomes etc

Total outcomes for the activity

Attribution

Total attributed outcomes for the activity

Future outcomes

What will happen in future as a result of effort/spend today?

Total attributed outcomes each year to 2020 for the activity

Overlaps?


Total attributed outcomes each year to 2020 for all activities

What happened as a result?

To what extent did WRAP's activity influence the outcomes?


Is there a risk of double counting?

Value for money / vantage points



### Examples of dependency in action

- Total impact of actions taken by businesses on carbon dioxide equivalent emissions is dependent on:
  - The material/waste in question
  - The nature of the action – how did they divert material from landfill (eliminated entirely, recycling, reuse)
  - Evidence about reduction in CO<sub>2</sub>e emissions associated with action
- Total impact depends on
  - Impact of individual activities
  - Whether and how this is expected to persist over time
  - Degree of overlap between outcomes for individual activities
- Value for money depends on amount spent on activity and impact of the activity...



## Agency

- Agency – many and various forms
  - Stakeholders and their activities*
    - Activities undertaken by WRAP
    - Funding provided by Defra
  - Environmental agents*
    - State of the economy
    - Technological/process
    - EU directives
- Current state of the model can be “best estimate” of:
  - Impact based on current evidence and understanding
  - Likely impact under different circumstances

## Model can be embellished ‘on the fly’

- Implementation in Excel allows:
  - Agents other than the modeller to explore the model and experiment
  - New definitions can be introduced or redefined as appropriate
- Ideal for us/WRAP/Defra as:
  - The context for WRAP’s activities is continuously changing
  - Priorities/interests change over time – green jobs
  - Understanding about influence, impact on the target audience and implications also improving in light of new evidence

## Minimal abstraction

- Minimal abstraction...
  - ‘Cells’ experienced as observables
  - Core model requires minimal use of Excel functions
  - In building most definitions, the modeller can refer to individual observables and is not required to think in terms of variables/algorithms
- ...though some abstraction cannot be avoided:
  - Macros are desirable to minimise the burden on the modeller for aspects of the model that are now unlikely to change between iterations. Macros require abstraction from the problem domain and expert input
  - Some statistical calculations (e.g. lower/upper bounds) require reference to abstract models ( $z=1.96$ )
  - Total ‘attributed’ figures are conceptual rather than actual

## Human interaction with computers

- No expert programmers involved in the work; stakeholders are less technical than we are
- Initial model developed by single modeller; subsequent models developed collaboratively
- Collaborative development in ‘formula language’, bring in ‘experts’ where necessary
- cf *Collaboration among spreadsheet users*, Bonnie Nardi, *A Small Matter of Programming*:

*“Typically, end users do most of their work within the formula language, and they are aided by local developers or programmers when they need macros, sophisticated graphs and charts, custom presentation formats, such as a new format for displaying cell values, formulas with advanced spreadsheet functions such as date-time operations and complex formulas, such as a formula with many levels of nested conditionals”*

## Efficacy and effectiveness, above efficiency

- The model does the job it is required to do; it could be more:
  - Efficient
  - Elegant
  - Sophisticated / comprehensive
- Not the goal to automate the policy decision making process

## Challenges

## Changing attitudes / culture

- One of the biggest challenges is getting clients to move away from thinking about the impact model as a repository of impact data and move towards them thinking of it as a tool for better understanding how they can achieve their policy/delivery objectives *c.f. McCarty's modelling machines vs knowledge jukeboxes*
- Short term challenge is to get clients to integrate the model in their decision making processes

## When to stop developing the model...

- Medium/long term challenge is to improve the accessibility of the model
- Reluctant to 'hard code' the model as we will lose:
  - Control over model development – insufficient in-house expertise to develop a program
  - Transparency of model definitions
  - Possibility of interaction beyond agreed use cases
- However, significant appetite for online version of the model

## Technical challenges / limitations of current model

- Achieving scale – employ macros to help us with this, but this requires support from a programmer
- Populating the model with the latest evidence
- Some limitations of spreadsheet implementation:
  - Large file size – takes up space, more difficult to transfer
  - Some performance issues, depending on:
    - Version of Excel used by modeller/stakeholder
    - Processing power / memory
  - Experimented with introducing charts / more visual representations; however:
    - Confined to charts provided by Excel
    - Required macro agents to change cell references in the background for more sophisticated charts so it referred to the correct observables/cell ranges

## Conclusions and closing remarks

## Policy making isn't a trivial exercise...

- Myriad of influences – political, social, economic, technological, environmental, legal
- Even if it were feasible to identify all of the factors that affect the outcomes of the policy / which policy might be the most successful:
  - Trade-offs / unanticipated consequences
  - Finite resources, opportunity cost of intervention
- Need for expert policy maker
- Significant need for computer-based support

## Empirical Modelling can help policy makers

- Empirical Modelling principles and techniques can be applied in helping policy makers to make effective decisions
- Moving away from knowledge jukebox to modelling machine; enables modeller to ask questions not pre-conceived
- Spreadsheet environment has limitations; however – no software in widespread use that we are aware of that better meets our needs/circumstances
- Challenge to computer scientists of the future is to make something better – Cadence?

## Any questions?



## Opportunities

- Databuild is always on the lookout for new recruits that can help us to deliver a better service to our clients
- If you are interested in working with us, and helping to further develop the impact model concept and implementation please send a copy of your CV to [karl.king@data-build.co.uk](mailto:karl.king@data-build.co.uk)



## Further information...

For further information, please refer to the following:

- **My construal of Empirical Modelling**  
Karl King *Uncovering Empirical Modelling*. MSc thesis, Department of Computer Science, University of Warwick, UK (January 2007).  
<http://www2.warwick.ac.uk/fac/sci/ics/research/em/publications/mschyresearch/kking/>
- **The Defra/WRAP impact model**
  - Karl King, Databuild, Harmonising impact assessment across delivery organisations, Article published in *The Evaluator*, spring 2011 *The Evaluator is the magazine of the UK Evaluation Society (UKES)* [http://www.databuild.co.uk/media/pdf/case\\_studies/file\\_443120755741.pdf](http://www.databuild.co.uk/media/pdf/case_studies/file_443120755741.pdf)
  - Rocky Harris, Defra, "Integrating evaluation and forecasting", Counting on Energy Programs: It's Why Evaluation Matters, Paris, France: International Energy Program Evaluation Conference, June 2010 <http://bit.ly/gTP374>
- **Databuild** - <http://www.data-build.co.uk>
- **Defra** - <http://www.defra.gov.uk/>
- **WRAP** - <http://www.wrap.org.uk/>

