Quantifying Human Behaviour

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1. SYNOPSIS

This paper considers ways of quantifying and modeling complex cultural factors and creating workable links between detailed ethnographic data and statistically based forms of analysis.

2. ABSTRACT

This paper considers the practical and intellectual challenges of attempting to quantify and model the complexities of human behaviour, focusing on current experimental attempts to integrate cultural and behavioural factors into the DECADE model of domestic energy use in the UK.
It looks at some of the complex, intangible, and often contradictory cultural factors that inform all individual and communal decisions and actions, for example: personal and family history, beliefs and values, processes of socialization, and knowledge acquisition. It outlines some methodologies through which these can be 'read' and correlated to construct detailed profiles of a variety of groups according to age, gender, and household type.
Various ways are then considered in which such profiles may be quantified and expressed as attributes in a model of domestic energy use. The potential of these attributes to expand the model's ability to predict responses to different policy scenarios is examined.
A sub-model is currently being developed which will be incorporated into the main DECADE model. This will evaluate a variety of policies and impacts on domestic energy use, ranging from plans for technical legislation (for example minimum standards), to directly educational efforts (such as energy advice and household auditing). Once the behavioural profile has been quantified, it will be used within the model to calculate parameters predicting the strength of each policy, its likely duration and the time it may take to become effective, thus ensuring that behavioural factors are incorporated into the modelling process.

3. INTRODUCTION

One of the central challenges for all environmentalists is to make sense of the relationship between cultural attitudes and values, and the choices that people make in their use of technology and resources, and in their dealings with the environment.
This paper considers a twofold problem: firstly, that of extracting from the vast complexities of any culture the significant factors that lead to particular environmental choices and, secondly, the systematic reduction and quantification of this largely qualitative data so that it can be incorporated usefully into predictive models such as the DECADE model of domestic energy use in the UK.
This model is intended to create a statistical analysis of UK domestic appliances' energy use (excluding space and water heating), bringing together data on households, appliance ownership and patterns of energy consumption in the home, and linking these with the domestic sector's contribution to UK CO_2 emissions. Its purpose is to evaluate a range of policy scenarios, and their potential for reducing CO_2 emissions in accord with the UK's environmental commitments. The model is therefore designed to give a predictive response to policy scenarios, once they are translated into a form which can be input into the model. It is intended that this work will form part of a European wide approach to modelling through collaboration with other EU members.
This paper outlines the DECADE team's interdisciplinary approach to the problem, and some of the methodologies that we are using, with practical emphasis on ensuring that cultural and behavioural factors are included in our statistical analysis of UK energy use and in our evaluation of a range of policy scenarios.

4. THEORETICAL BACKGROUND

If we accept the premise that there is a causal relationship between the beliefs and values subscribed to within cultural groups, and the behaviour that expresses these, we must also assume that there are significant factors leading to the formation of those beliefs and values. This suggests a sequential process from significant factors, to beliefs and values, to behaviour. The development of human culture is a continual process based on a dynamic interaction between each cultural group and its environment, and between a range of influential factors, constantly evolving values, and behaviour.

The fields of both anthropology and psychology have established that beliefs and values are acquired through a process of socialisation. People are socialised through interaction with a range of cultural forms - not just educational systems, but also history; media; the imagery with which each culture surrounds itself; the moral structures of society; group identity; religious or scientific beliefs, perceptions of the environment, and so on. In other words, they acquire their beliefs and values through living within an environment of ideas, many of which are primarily symbolic and intangible. These intangible, but immensely powerful cultural forms mediate the more down-to-earth human interactions with the environment, such as economic activities, material culture, and responses to natural environmental pressures, (for example climate).

Human attitudes towards the environment - and actions which result from such attitudes - can thus be seen to emerge from a dauntingly complex mixture of cultural forms, environmental pressures and (many would argue) fundamental human needs and desires.

Within this range of cultural factors, some will tend to support concern for the environment and encourage people to act in ways that conserve energy, protect resources and generally take care of the environment. Others will work against the development of such environmental concern. Recent anthropological research comparing cultural groups which have strikingly different environmental relationships (Strang 1994), suggests that it is possible to pinpoint some of the most influential factors in the formation of differing levels of environmental concern. In very general terms, these include factors such as:

~ type/stability of tenure and continuity of residence
~ level of commitment to the local environment
~ local community involvement
~ religious or moral beliefs, concepts on environmental responsibility
~ worldviews and concepts of nature
~ processes of socialization - sources of environmental knowledge and values
~ personal values and aspirations
~ general knowledge and perception of environmental issues
~ knowledge and understanding of energy issues
~ understanding of technical and cost related aspects of energy use
~ household decision-making and social dynamics

This preliminary definition of the most important influences makes it feasible to begin tracing the relationship between these significant factors, the development of attitudes and values regarding the environment, and the choices and actions through which these are expressed. As well as potentially offering some predictive capacity in our current evaluation of policies, this approach has obvious implications for the development of long-term policies and programmes that will be successful in encouraging wider concern for the environment.

The incorporation of a behavioural aspect into the modeling process therefore depends on the successful completion of several stages:

~ the identification of key influential factors
~ a systematic analysis of the relationship between these, attitudes   and values and the behaviour itself
~ the quantification of this data in a form suitable for entry into the DECADE model.

5. CREATING A HOLISTIC DATA SET

One of the major obstacles to the introduction of cultural and behavioural factors into mathematical models is the lack of data that chart the development of the relationship between significant factors and behaviour, from the large and often intangible cultural or social factors to the attitudes and values that are created by these, and so through to the many precise and practical actions that comprise human interaction with the environment - for example, appliance purchasing decisions, or the small everyday decisions involved in using energy in the home.

In creating a complete picture of domestic energy use in the UK, it is relatively straightforward to obtain the 'hard' data, although there are some awkward gaps. Ownership data is available from several published sources (and the accuracy can be enhanced with additional confidential data). Data on energy usage patterns and trends are scarce and only available from small scale research surveys. For example, DECADE is making use of a highly detailed small-

scale survey currently underway in Edinburgh, which offers opportunities for detailed measurement of actual household usage patterns, so giving a predicted energy use.

In terms of behavioural aspects, a few ethnographic surveys have examined attitudes and values, and tied these to specific kinds of environmental actions (for example, Hedges 1991, Kempton and Neiman 1987, Kempton 1991, Sadler and Spencer 1982, Sadler 1991,). There are also some small-scale surveys reliant on more statistical social science techniques (for example, Bagshaw 1981, Meyel 1987) and some that combine both ethnographic and statistical analysis (Brandon 1993). These are informative, and in some instances have developed useful profiles or typologies systematically describing people's attitudes. However, because of the highly detailed data required, the majority of these surveys are very small in scale. They also tend to be heavily reliant on deductive hypotheses rather than quantitative analysis, making it difficult to extrapolate their findings to larger populations through the use of wider statistical methods. Additionally, despite the more detailed nature of the fieldwork, they largely fail to go beyond the stated attitudes to delve into why and how people arrived at their particular beliefs and values, or to confirm a link between attitudes and behaviour.

Alternatively, some very large-scale surveys, often carried out by market research companies, ask people about their attitudes or values, and in some cases look for indicators of 'green behaviour' (for example, Department of the Environment 1993, Institute for Fiscal Studies 1992, Worcester 1994). These approaches are invariably highly reductionist and quantitative. In some cases they have devised useful definitions of 'green activists' or 'green consumers' according to specific criteria - usually based on action indicators such as the purchase of 'environmentally friendly' products or recycling. However, they provide little or no contextual background about the respondents, and thus little insight into how or why they might - or might not - prioritise their environmental concerns. Thus, like the smaller but more detailed ethnographic approaches, their analysis of the relationship between cultural influences and actions is confined to the links between attitudes and actions, falling short of considering factors that might be formative of both of these.

This polarised nature of these approaches and the consequent fragmentation of the data reflect the basic difficulty of conducting more than superficial social studies on a large scale, and of devising suitable methods of quantifying non-technical or qualitative data.

Our major aim has been to obtain a holistic data set that follows the relationship from cultural factor right through to action, and to quantify this data so that it can be extrapolated into the larger scale statistical models essential to policy evaluation. At the same time, we accept that the complex issues of cultural influences, the formation of environmental beliefs and values, and the expression of these, demand an approach which has both breadth and depth. It is for this reason that we are attempting to combine qualitative ethnographic methods and approaches with more numerical social science techniques.

6. APPROACH

A first step has been to establish the 'hard data' that will ground the less tangible kinds of information that constitute behavioural analysis. This will provide the basis for incorporating smaller but more detailed survey material into the broader structure of the DECADE model. This data category includes:

~ background data on households and their occupants, such as household size, location, dwelling type, and occupants' age, gender, education level, socio-economic category, etc.

In accord with the sequential process discussed earlier, the rest of the data set can be organised into 'chronological' areas. These are:

~ cultural factors defined as influential
~ stated attitudes and beliefs
~ actions - indicators of environmental concern, such as recycling, purchase of energy efficient technology, 'environmentally friendly' products. Usage patterns (providing indicators of conservation measures). Actual consumption vs. National Home Energy Rating (NHER) predicted consumption levels
~ receptivity to presented policy scenarios

This organisational structure facilitates the search for correlations between each area, between the influential factors and stated attitudes, between both of these and specific actions, and of course between each of these areas and the levels of policy receptivity.

The inclusion of background data on the respondent groups ensures that their profiles can be linked to 'hard' national data such as age group, household type, appliance ownership, social classification and suchlike, so simplifying the task of extrapolating more detailed survey work to a wider population.

The 'hard' background data is readily quantifiable, and each category contains well established conventions of measurement. It is also relatively straightforward to compile a checklist of action indicators which give a 'green rating' both for individual respondents and households. However, most other data areas are based on essentially qualitative information; values and beliefs are invariably heavily subjective, with wide variations on what people

consider to be a high or low level of concern or involvement. It is in these most abstract and complex areas that the constraints force the numerically-based analysis to be most reductionist.

One solution to quantifying the behavioural aspects of environmental concern and domestic energy use is to assign systematic weightings to the range of response data, relying on familiar social science phraseologies such as 'agree strongly, disagree, disagree strongly,' etc. This permits rating of levels of knowledge, concern and involvement accordingly, and provides overall ratings for each area. A consistent rating system will assist in the search for significant relationships between them.

The most problematic area for quantification is, not surprisingly, the broadest and most complex data - the 'significant cultural factors' (as defined previously). Being drawn from recent comparative ethnographic analysis, the 'significant factors' have yet to be tested within a statistical framework. Initially - like 'green actions' - these may be treated numerically as a checklist of 'indicators' or given a standard weighting. However, although this provides a preliminary framework for analysis, it has limited value since it presupposes that each factor is of equal influence, and that their weight of influence is unaffected by different combinations.

Such data can only be refined by the use of a methodology which examines the consistency between the significant factors, the development of particular kinds of beliefs and values, and actions expressive of environmental concern. Such an approach will doubtless lead to some modification of the 'significant factors' list. More importantly, it will supply a feedback loop, permitting more appropriate weightings to be iteratively assigned to each factor.

7. METHODS

7.1. Quantitative Methods

Most of the data for the DECADE model has been gleaned from other sources - the Electricity Association, the Consumers' Association, statistics from various Government Departments and private market research companies. However, the requirement for a data set reflecting each part of the relationship between cultural factors and environmental actions has led the DECADE team to initiate a survey of its own. Given the time and budgetary constraints, this first survey is necessarily small in scale, covering only 100 households, but it is hoped that a larger survey will follow at a later stage.

The present survey focuses on a sample population drawn from recent fridge/freezer buyers. While this obviously imposes some limitations on the cross-section of the population that can be achieved, every effort will be made to elicit data from as wide a range of household and respondent types as possible from within this group. The advantage of focusing on fridge buyers is that it allows us not only to evaluate an actual policy - energy labelling - but also to test the effectiveness of our evaluative methods.

In compiling the data, use is made of a detailed questionnaire covering each data area. The questionnaire employs checklists and some multiple-choice questions, and illustrations of various policy scenarios assist the 'policy receptivity' section.

If profiles can be matched with similar attributes in the population as a whole (i.e. with the 'hard' data) the survey results will then have a predictive capacity. This is no simple task; techniques employed to perform this matching will include correlations, factor analysis and other multi-variate techiques. There will be some problems of multi-collinearity (i.e. correlations between variables) and some data reduction will have to be performed.

At this stage it may also be advantageous to take the broad-scale attitudinal data already available and use it to define a 'template', providing a norm against which the more detailed profiles can be measured.

Once the initial survey has been analysed, a logical next step is to refine the questionnaire further and conduct a much larger survey encompassing a wider cross-section of households in different regions.

7.2. Qualitative Methods

As well as asking people to fill in the questionnaire (described above) to provide us with readily quantifiable responses, we are also conducting ethnographic interviews in the respondents' own homes. This has been organised in several stages:
> ~ inviting people to participate in the study (using a leaflet disseminated through cold appliance retail outlets)
> ~ 'follow-up' phone calls and post code analysis, constructing a representative sample population from the pool of respondents
> ~ sending respondents the preliminary questionnaire by mail and arranging an interview
> ~ conducting in-depth ethnographic interviews with each household

The interviews will be structured around a series of open-ended questions, but will not be hidebound by them, thus permitting fuller exploration of the issues and the areas prioritised by the respondents.

With this combination of techniques, the more reductive data collection is supplemented by in-depth ethnographic information, permitting contextualisation of the data and greater insight into the complexities of environmental values and their effect on energy use.

Throughout the process some qualitative analysis will be carried out. As with the quantitative analysis, the aim will be to reveal any important correlations between the various data areas, and to develop a consistent methodology for extrapolating the results to a wider population.

Although only a preliminary qualitative analysis can be included within the current time-frame of the DECADE project, a more in-depth qualitative analysis of the data is intended to follow the initial construction of the DECADE model, filling in the gaps which are inevitable in the reduction of complex cultural data to numerical forms. As well as rounding out the numerical analysis in this way, a qualitative perspective will probably suggest alternative ways of examining and grouping the data, thus assisting further statistical analysis.

7.3 Incorporating quantitative and qualitative data into the behavioural sub-model

If we match profiles with similar attributes in the 'hard' background data, then the behavioural data will be integrated into the DECADE model via a sub-model, by treating the individual or household profiles and their rated 'policy receptivity' as secondary attributes. Their respective rated policy receptivity will then be used to predict how the defined groups will react to different policies.

It is likely that different groups will react differently to the same policies. To model these effects the modelling will take the form of a transfer function model1 which allows for dynamic effects due to simple policy inputs. The transfer function model is defined by some parameters, which reflect behavioural factors and together describe the maximum short-term gain (effect) and the steady state long-term effect of the policy (which drives the model). The duration of the effect is also described by these parameters, and a lag parameter (i.e. the time delay d) may be introduced. This is not too different from the economists' view of short-term and long-term price elasticity of demand, except that relationship between policy and effect is defined through time.

For example with a policy of an information campaign to increase the use of energy efficient light bulbs, the input is the information policy and the output is the increase in the number of these light bulbs bought by each of the groups.

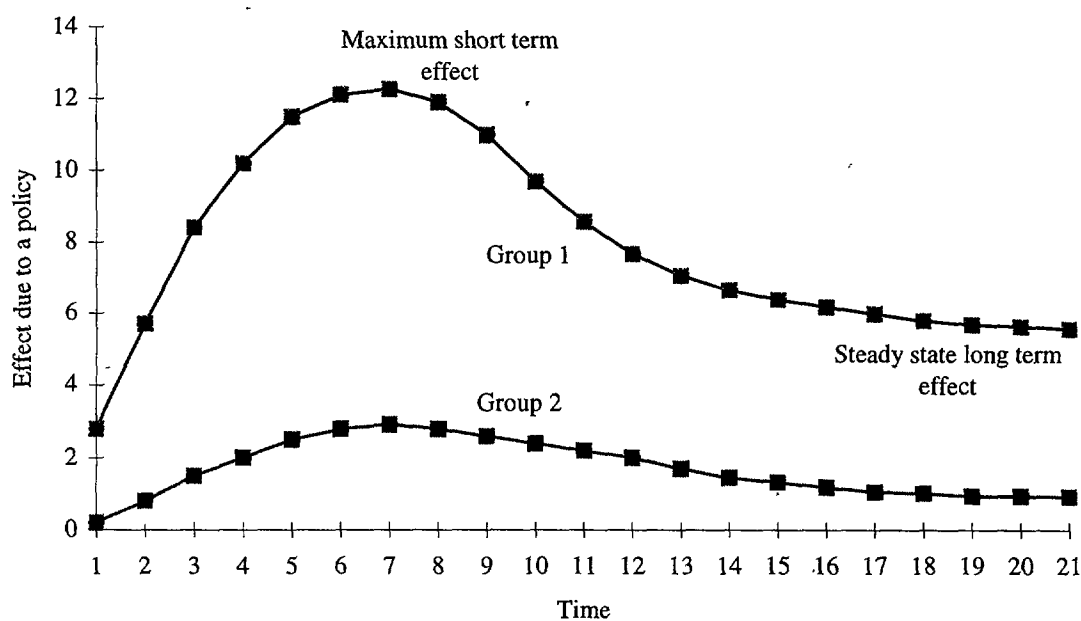**Figure 1:** *The effect of a policy on two groups*

Figure 1 shows the effects on two groups of a step input (e.g. a change in policy, such as the information campaign on the purchase of energy efficient light bulbs). The first group is more receptive to this policy than the second group. In this simple two-group example the differences between the groups could include varying levels of issues, concern for the environment and understanding of the technical and cost related aspects of using these light bulbs (e.g. simple pay back periods). Greater levels of concern etc. by group 1 will mean a stronger reponse to the information campaign and a higher increase in their purchasing of these light bulbs than by group 2.

Such relationships between policies and effects will be defined (i.e. model parameters identified and estimated) for each of the described groups using the weightings from the identification process and in some cases from case studies, where policies have been observed. In other cases, expert judgment may have to be provided to determine the magnitude of some of the effects of policies.

Once these differing 'reactions to' or 'effects of' policy have been established they will be used to perturb the 'hard' variables within the DECADE stock model of domestic energy consumption. The principal variables that will be perturbed are sales and ownership levels of domestic appliances, technical performance and usage patterns of these appliances.

8. CONCLUSION

The DECADE team's research in this area is not yet complete, but we anticipate that the work described above will create a preliminary (albeit still experimental) behavioural element within the DECADE model. This is essential if the socio-cultural aspects that are so vital in determining the success or failure of environmental policies are to be included in the analysis of domestic sector energy use.

Beyond the more immediate aims of the DECADE project, this work will also provide essential feedback on the proposed 'significant factors' that form the environmental beliefs, values and actions of each cultural group. A clearer definition of these factors is likely to be invaluable to future policy development, encouraging policy and decision makers to focus more clearly on the causes (rather than the outcomes or 'symptoms') of the social values dominating their particular culture's interaction with the environment. In practical terms, the quantification of these significant factors will allow them to be incorporated into the broad scale statistical analyses which inform policy.

9. ACKNOWLEDGMENTS

ENDNOTES (Footnotes)

1. The highest order of transfer function that will be used is second order and takes the following form:

$$y(k) = \frac{b0 + b1z\text{-}1}{1 - a1z\text{-}1 - a2z\text{-}2} \quad u(k\text{-}d) + e(k)$$

where

      u(k), the input, is the magnitude to the policy at time k

      y(k), the output, is the effect of the policy at time k

      b0, b1, a1, a2 are individual behavioural parameters of the model to be estimated, some of which may be set to zero to simplify the model

      d is the time delay of the policy

      e(k) is the part not explained by the model

and the backward shift operator, z-1, is given by

      z-i y(k) = y(k-i)

For a treatise on the subject of time series analysis see the classic monograph by Box and Jenkins (1976). A more accessible account and introduction to the subject is given by Chatfield (1989).

10. REFERENCES

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