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Improving scenario methods in infrastructure planning: A case study of long distance travel and mobility in the UK under extreme weather uncertainty and a changing climate

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ABSTRACT

This paper develops a mixed method approach to infrastructure planning through a United Kingdom (UK) case study examining the impact of a changing climate on long distance travel and mobility between London and Glasgow. A novel combination of a qualitative method - Systematic Qualitative Foresight (SQF) - and quantitative simulation using discrete choice stated preference methods is applied. The main dataset is a travel behaviour survey of over 2000 residents of London and Glasgow. Three illustrative SQF-based scenarios are developed incorporating society, technology and climate dimensions. For each scenario, the choice of long-distance travel mode by two groups of respondents generated by cluster analysis is simulated using stated preference survey data to describe the choices likely to be made by actors within each scenario.

We demonstrate the importance of considering a wide range of variables when creating instruments for infrastructure planning decisions. Our results show that weather-related disruption has consequences for travel behaviour, with a considerable number of travellers deciding not to travel despite the importance of their trip. However, the vast majority of travellers would still travel. This should be considered by policy makers, and those responsible for transport infrastructure, in order to increase its resilience to extreme weather and demand, and better devise contingency plans to contain, and minimise, the effect of the disruptions on the users. The method described has wider implications for infrastructure planning, particularly in its ability to engage a broader range of stakeholders and to avoid linear models of prediction. By emphasising the creation of a plausible decision space, it offers the possibility of increased robustness and resilience in infrastructure planning.

1. Introduction

A key problem in making planning decisions about major infrastructure projects is the potential length of the investment cycle. Transport systems are a particularly good example. At the extreme, the route decisions of Roman military engineers dictated the broad outline of the English road network until the construction of motorways in the 1960s. United Kingdom (UK) railways are still constrained by the technological limits of Victorian civil engineering in boring some of the tunnels that modern rolling stock must pass through. This is a specific case of a general problem familiar to social scientists, namely how societies manage to make investments in the present that will have to function in an unknown, and unknowable, future. If these decisions are wrong, then resources that could have been put to better use have been wasted. However, if the investments are not made, then their potential benefits are also foregone. All documented human societies have developed institutions and technologies to attempt to limit these risks by reducing uncertainty about, or stabilizing, the future. In traditional societies, stabilization may be achieved by consulting institutions like oracles or prophets, or by technologies like prayer and sacrifice. Modern societies have created institutions like insurance markets, based on the mathematics of probability,

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and technologies like econometric or demographic modelling, based on the identification and enrolment of various metrics into an algorithm. These have, however, been criticized for their reliance on data about the past as a guide to the future and for their tendency to foreclose choices about the future by a focus on technical expertise rather than public engagement. The future is produced by impersonal metrics rather than democratic consent. At the same time, many of the alternatives, in the form of scenario-based activities, seem to be based on little more than the values and preconceptions of their authors.

This paper reports on a different alternative approach, based on our work for FUTURENET, an interdisciplinary project linking engineers, geologists and social scientists to investigate the future resilience of the UK transport network in the face of climate change. The route corridor from London to Glasgow was chosen by the project team as a case study because of its importance for the UK economy, and its diversity of climatic and geographic conditions. The social science component considered long distance travel demand under potential climatic, social, economic and technological conditions, in order to characterize the needs that present-day infrastructure investments should expect to meet in the year 2050.

Transportation research has generated numerous quantitative prediction and forecasting studies of travel behaviour and vehicle choice typical of the approaches mentioned above (see for example Van Nes et al., 2008; Amstrong, 2006; Garrido and Mahmassani, 2000). A number of studies have also used scenario analysis, backcasting, Delphi and other methods from the future studies literature that variously adopt either exclusively qualitative or mixed qualitative/quantitative approaches (Hickman and Banister, 2007; Stead and Banister, 2003; Hickman et al., 2012; Zanni and Bristow, 2010; Tran et al., 2013; Lyons and Goodwin, 2014). The future studies literature has examined the possible evolution of urban transport systems and mobility practices (Inayatullah, 2003; Wangel et al., 2013; Moriarty and Honnery, 2008; Potter and Skinner, 2000), and, in particular, of the role of technology (Hubbers and Lyons, 2013), and fuel and energy sources (Charles et al., 2011; Suominen et al., 2011; Kivits et al., 2010). We have, however, been unable to identify specific studies of long distance travel, although some have discussed more general tourism patterns (see for example Butler, 2009; Yeoman et al., 2009). While some studies have looked at the broad issue of extreme climate events (van Koppen et al., 2010), the specific effects of extreme weather events on travel behaviour have not been examined. Very recently, a number of experts in transport have again stressed the limits of traditional quantitative forecasting models at taking into account the variety of determinants of travel demand, as well as those of more qualitative approaches seeking mere consensus among often considerably different opinions in a particularly uncertain world (Lyons and Goodwin, 2014). Our work for FUTURENET responds to these critiques with the development of an innovative methodology that transcends conventional qualitative/quantitative distinctions by establishing a protocol for integrating diverse types of information at the point of decision. This methodology is capable of extension to the assessment of other types of major infrastructure investments.

This paper demonstrates the combination of a qualitative method called Systematic Qualitative Foresight (SQF) (Goulden and Dingwall, 2012) with quantitative simulation using discrete choice stated preference methods on a large dataset in order to simulate the choice of method of travel over a number of multi-dimensional scenarios. Potential investment decisions can then be tested for resilience under different possible demand conditions rather than being constrained to generate a single vision of the future. The next section describes the methodology and methods employed in more detail. Section 3 presents the case study and some illustrative results from the simulation. Section 4 reviews the lessons from this study and considers how it might have more general application to planning large-scale, long-term infrastructure investments.

2. Background and methodological approach

In seeking to improve the planning tools available to those responsible for decisions about long-term investments in infrastructure, we specified a number of criteria that an approach should meet.

1. It should ensure that decision-makers consider a full range of socio-technical possibilities, particularly the interactions between their sectoral decisions and developments in other sectors of society.
2. It should be capable of accommodating as much available data as practicable, whether quantitative or qualitative.
3. It should be transparent with respect to the values taken into account by decision-makers.
4. It should be consistent with well-established social scientific evidence on human social organization.
5. Where required, it should be capable of supporting public engagement and dialogue to test expert thinking against lay reasoning, and aid the legitimacy ascribed to its conclusions.

Our approach integrates qualitative scenarios with econometric simulation based on primary data collected through an extensive population survey. Quantitative forecast and prediction modelling generally rest on the assumption that variables and relationships that have been measured and linked in the present, or in the recent past, can be used to predict the future. This has been described as ‘up-and-to-the-right’ thinking, where lines on a graph are simply continued in the direction that has been established (Bleecker, 2009). There are two particular problems with this. First, it cannot be assumed that any trend will continue indefinitely; late 19th century city governments feared a crisis from the increasing volume of horse manure being deposited on their streets but this was prevented by the introduction of automobiles (Morris, 2007). Second, the social sciences cannot sensibly impose metrics on some dimensions of social and economic life; a purely quantitative approach will inevitably exclude important data that do not lend themselves to numerical representation (Cicourel, 1964). In this respect, our approach contrasts with the XLRM framework developed at RAND, which attempts to reduce all inputs to numerical forms, while accepting the need to generate a decision space rather than a linear vision of the future (Groves and Lempert, 2007; Lempert et al., 2006). Recognition of these limitations has led to the parallel development of qualitative approaches.

The earliest of these, represented by the ‘genius forecasting’ developed by Herman Kahn and the RAND Institute during the 1950s (e.g. Kahn and Wiener, 1967), sought to produce systematic and supposedly objective scenarios, based on explicit methodological protocols, to displace the subjective visions exemplified by the work of novelists like Jules Verne or HG Wells. The Delphi method (Linstone and Turoff, 1975) sought to progress this approach through the consolidated wisdom of key stakeholders, who are each asked to make their best individual predictions. The predictions are combined and weighted to give a pooled estimate of likely futures. The pooling process may include a number of iterations with the participants, seeking to build a consensus around the estimate. These methods can be invaluable in provoking questions and debate. However, they also have limitations as means of stabilizing the future. Expert forecasting depends heavily on the choice of experts who are consulted, which tends to incorporate unexamined normative assumptions about what counts as expertise. Moreover, the emphasis tends to be on seeking consensus rather than on finding options capable of accommodating diversity. In some technology design circles, these limitations have led to a revival of interest in the use of science fiction to propose ‘what-if’ questions to designers and policy-makers (Bleecker, 2009; Johnson, 2011). This method attempts to envision alternative societies where a particular technology or social theory has, or has not, come into use. The use of creative or imaginative perspectives is particularly helpful in stimulating innovative thinking. However, these narratives also tend to impose closure on the