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Using agent-based models to design social marketing campaign

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ABSTRACT

Community-based social marketing (CBSM) involves members of the community as active participants in the marketing campaign for a social good. However behaviour of community members in CBSM is not well simulated using the standard tools available to marketers. We show how agent-based models (ABMs) can be used to simulate the behaviour of community members at the individual level to determine how sensitive the outcome of a CBSM campaign is to assumptions around the effectiveness of marketing within the community. We develop an ABM for wetlands managers to use to simulate the outcome of a marketing plan for promotion of environmental tourism in a wetlands area. The wetlands managers must trade off the costs of marketing and the damage done by the tourism activities with the value of ecotourism for the wetland. We find evidence from the simulations that wetlands' ecological health is sensitive to the design of the social marketing campaign.

摘 要

基于社区的社会营销(CBSM)在市场促销中吸引社区成员积极参与能为社会带来好处。但是，采用为营销人员提供的标准工具来模拟CBSM中社区成员的行为效果不佳。我们演示如何采用基于主体建模(ABM)来模拟社区成员的个人行为，围绕社区营销效果假说，判定CBSM促销效果的敏感度。我们为湿地经理开发了一套ABM，采用这个方法模拟在湿地地区促进环境旅游的营销计划效果。湿地经理必须权衡营销成本及旅游活动对湿地所造成的破坏与生态旅游所带来的价值。我们从模拟中发现的证据表明，湿地生态健康对社会营销设计反应敏感。

1. Introduction

The management of environmental tourism, or ecotourism, is a primary challenge for managers of areas of high environmental value (Lim and McAleer, 2005). Ecotourism has benefits for the areas – both in terms of additional fee revenues for the area's management but also in terms of raising the public profile and increasing political support for protection of the area. However the activities of the tourists will have a negative impact on the area due to land and water use, generation of waste, noise and other effects associated with tourism. These tourism activities degrade the same environmental assets the tourists are there to enjoy (Lynn and Brown, 2003). Managers of the areas then have to balance use of the area with the needs of environmental and economic sustainability to achieve the goal of "ecologically sustainable tourism management."

Community-based social marketing (CBSM) has been put forward as a marketing approach which could be of use to site managers in designing marketing campaigns to promote tourist visitors to their sites. CBSM (McKenzie-Mohr and Smith, 2011; McKenzie-Mohr et al., 2012) draws from research in social psychology to identify barriers to uptake of social marketing messages and communication strategies to overcome these barriers. It is hoped that the use of community-based mechanisms could overcome the traditional finding that information-based campaigns are ineffective in changing household behaviour (McKenzie-Mohr and Smith, 2011). CBSM frequently makes use of communication channels within the community targeted ("social diffusion"), such as requesting those households already engaged in the activity to contact others about the campaign (McKenzie-Mohr and Smith, 2011).

The design of a marketing campaign using CBSM however is hampered by the lack of tools to model the social diffusion of the campaign messages within the community. Previous CBSM research has used surveys and regressions to analyze household uptake of programs, however these methods are of limited use in

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predicting the impact of interactions between individuals in a community. Communication of the marketing message within the community is essentially a "black box".

Agent-based models (ABM) are a simulation tool built around the behaviour and interaction of individual agents. Using an ABM, marketers can explicitly model the behaviour of individuals, the interactions between individuals in a community and the social diffusion of marketing messages. This method could be of use to marketers and managers designing social marketing campaigns with community-based communication. We present the results of an ABM for an ecotourism area: the Winton Wetlands.

The Winton Wetlands is an 8750 ha transformed wetland site, located in the Goulburn-Broken Catchment in North-East Victoria, approximately 200 km north of Melbourne, Australia. In 1970, it was transformed into an artificial irrigation reservoir, Lake Mokoan, with the construction of a dam. Due to its inefficiency as an irrigation reservoir (increasing turbidity, algal blooms, and water losses), the State Government decommissioned the dam in 2004 (Goulburn Broken Catchment Management Authority, 2012).

After the decommissioning, the state Minister of Water established the Winton Wetlands Committee of Management. This community-based organization was charged with the preparation and implementation of two projects aiming to return the Winton Wetlands to its natural state as an important wetland system (approximately 2900 ha of Red Gum woodland were destroyed with the construction of the dam) and develop the site as a sustainable nature-based touristic wetland.

The Winton Wetlands restoration project is an ideal case for this study because it is currently in the beginning stages of restoration and development of nature-based tourism. Furthermore, sustainable development and inclusion of stakeholders is deemed as important and the community has shown significant interest in taking part in the decision-making process.

2. Agent-based modelling and community-based social marketing

2.1. Agent-based modelling

Socio-environmental systems, such as those involving nature-based tourism, are dynamic, multi-scalar systems, which include interacting environmental, social and economic aspects (Musters et al., 1998). Socio-environmental systems are also complex, whose full description is impossible, where prediction of changes is difficult and unexpected changes are likely (Gibson, 2006). To overcome these difficulties, ABM is used to determine the behaviour of autonomous agents, whose interaction with other agents and the environment gives rise to the behaviour of the system as a whole (Bonabeau, 2002; Scholl, 2001).

Simulation has a long and distinguished history in Science, Technology, Engineering and Mathematical disciplines. Engineers build bridges and design aircraft, largely by computer. Economists and social scientists are increasingly optimistic that we can achieve similar goals using ABM for social systems of all kinds. There has certainly been substantial progress.

The Santa Fe Institute, founded by Nobel Laureates, Murray Gell-Mann (quantum electrodynamics) and Philip Anderson (disordered systems), played a foundational role in the development of complex systems as a discipline and fostered the early development of agent-based modelling. We can distinguish three different levels of agent modelling: canonical systems; heuristic ABMs (HABM), which are heterogeneous agent models using domain knowledge and heuristics for diving agent behaviour; and data-driven ABMS (DABMS), in which quantitative studies and big data parameterize agent behaviour in an attempt to get closer to the engineering goals.

2.1.1. Canonical systems (CABM)

Complex systems are interesting because diverse and particular behaviour can emerge from simple agents and interaction rules. Thus, such behaviour emerges in very simple, canonical systems. Of these, the best known are cellular automata (CA). Jon Conway's Game of Life, found on many computer systems (Berlekamp et al., 1982; Gardner, 1970) produces extraordinary patterns (Wuensche, 1998), characteristics of many co-called complex cellular automata (Wolfram, 1986). Since CAs have found applications in many areas from traffic (Nagelocd and Rasmussenaf, 1994) to soil erosion (Di Gregorio et al., 1999) and urban planning (Clarke, 1997). Stuart Kauffman introduced Random Boolean Networks (RBN) (1993) for modelling gene regulatory networks, but they have now spread far and wide, even reaching into management and organizational science (Rivkin, 2001).

2.1.2. Swarm and its progeny

Chris Langton, who made a seminal contribution to the understanding of CA complexity in his famous *Computation at the edge of chaos* paper (1990), saw the future need for agent models, which embodied multiple agent types, diverse behaviour and varied interactions. He convened the SWARM workshop at Santa Fe, from which the first serious ABM package arose, driven to completion by Nelson Minar. SWARM was written in Objective C, at the time primarily on the NEXT Platform. NEXT, a Steve jobs company, disappeared but its software morphed into MAC OS X and Objective C carries on with the Apple Community. But at the time it was overshadowed by C++, which still has a larger user base. Hence it was not until SWARM was rewritten in Java as RePast, that it became really popular. Since then, a range of ABM platforms have appeared. Leigh Tesfatsion's website (Tesfatsion, 2013), an outstanding resource for ABM, has numerous examples. Netlogo (Wilensky, 1999), the platform used in this paper, is an excellent compromise between power and user tools, and intelligibility and usability for those who are not IT professionals. These packages support HABMs and can be infused with qualitative data from interviews and surveys.

2.1.3. Generative social science

Although engineering simulation seeks quantitative predictions, Joshua Epstein argues that prediction is not necessary an essential outcome of social science simulation (J. Epstein, 2008). Because of difficulties of parameterization and the insurmountable Popperian issues of the growth of human knowledge, a minimal desirable outcome is the generation of macro-level social observables from micro-level agent behaviour and communication. Predicting emergent behaviour in complex systems is inherently difficult. Thus finding the low level drivers of systems to produce observed outputs is usually non-trivial. Thus the sweet spot for ABMs at present are HABMs, which successfully describe *trends and transitions* rather than precise quantitative metrics. Examples abound, in Epstein's book (2006) for anthropology, Paul Ormerod's work in economics, with examples in books such as *Positive Linking*, or diverse social phenomena in Nigel Gilbert's *Agent Based Models* (Gilbert, 2008).

2.2. Modelling social behaviour for community-based social marketing

CBSM is an approach to marketing adopted from research in social psychology, which aims to identify barriers for the uptake of marketing messages, as well as communication strategies to overcome these barriers (McKenzie-Mohr and Smith, 2011). For CBSM, individuals are embedded in a social, political, environmental and