SIMULATING SOCIAL NETWORKS IN SOCIAL MARKETING

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ABSTRACT

Community-based social marketing is a relatively new approach in marketing which makes use of social networks within communities to disseminate marketing messages in a information campaign. Agent-based models can be used as a tool for exploring the sensitivity of such campaigns to the structure of social networks within target communities. We develop an agent-based model for a social marketing campaign within surrounding communities for ecotourism services in a wetland. As the revenues from ecotourism are used to fund the rehabilitation efforts in the wetland, the long-term sustainability of the wetland is dependent on the success of the marketing of the ecotourism services. We find that for a small world social structure the success of the social marketing campaign is highly dependent on the number of links between communities. The results suggest that the design of social marketing campaigns may need to take account of social networks between and within communities.

INTRODUCTION

Ecotourism has been a rapidly growing area over the last couple of decades. Thus it generates a stimulus to recover derelict areas which have the potential to create interesting ecological environments. The Winton Wetlands, the subject of this paper, is one such area.

Ecotourist areas need tourists to generate revenue to support their upkeep and further development or rehabilitation. However the tourists' consumption of ecotourism services often causes damage to the same environmental services the tourists are there to enjoy, through water or noise pollution, wastes and simple disruption of the environment. Ecotourists also demand non-ecological facilities, from the most basic needs through to coffee bars, restaurants, coffee shops, information kiosks and helpful rangers to provide on-the-spot information within areas of high ecological and biodiversity value.

Getting the right balance is difficult between the desire for ecotourists to have access to areas of high ecological value, the financial need in terms of long-term sustainability for the revenues that come with those ecotourists and the protection of those ecological values in the areas which make them so attractive to ecotourists. This paper argues that simulation, specifically Agent Based Modelling, is a good way to explore the strategic options available to natural resource managers. In fact the simulation suggests a non-intuitive finding as to the requirements of the most effective marketing.

This balance has been explored using a system of differential equations elsewhere [LPCZ07]. But such a systems-dynamics like approach is unable to capture the diversity of behaviours in a complex system, which in this case is a combination of an ecological system of a wetland and a human system of a marketing effort in an attempt to attract ecotourists. Any attempt to model such as system must include details of both the human social networks and the community-based marketing effort and the details of the wetland itself.

Social Networks

One exciting trend of the last two decades has been the understanding of networks and network structure, summarised in Paul Ormerod's recent book [Orm13]. Two formative developments were the introduction of *small-world* networks by Watts and Strogatz [Wat99] and *scale-free* networks by Barabási [Bar02]. Network studies have spread to many areas, from the study of pandemics [GKLM06] to the appearance of small-world structures in language [FiCS01]. Numerous methods now exist for eliciting social network structure [KW06].

Small world and scale-free networks have a property in-common, their low distances between nodes, where distance is defined as the number of hops between connected nodes to get from one node to another. In small-world networks these short paths arise from short cuts, a bit like the snakes and ladders of the popular children's board game.

There are many ways of defining a small-world network structure. The one we use here is to start with a regular network with each node connected to a small number of neighbours. Then links are broken at random, forming a new link to some other random location. The number of such cuts, N_c determines how short the average path length becomes. Quite small values of N_c lead to low path lengths, as encapsulated by Milgram's famous *six degrees of separation* experiment [Mil67].

Scale-free networks achieve this in a different way, through having highly connected *hubs*. The quintessen-

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tial example would be the airport network. To fly from some small airport in Russia to another in the USA, would usually involve flying in and out of hubs, say Moscow and JFK, both of which connect to many airports.

Community-based social marketing

Social marketing is a subdiscipline of marketing which seeks to influence human behaviour to achieve some social good or to ameliorate some social problem using marketing tools [KZ71], [KL11]. Social marketing has been proven of use in many public campaigns to address problems such as drink driving rates, teen smoking rates or low use of mosquito nets to combat malaria [KL11].

In contrast to more traditional public information campaigns which typically make use of mass media, community-based social marketing (CBSM) uses existing social networks between tourists to disseminate marketing messages [MM00], [MMS11]. Such campaigns may be less expensive to run without the high cost of purchasing space within the mass media but are dependent on social networks for their dissemination.

In a typical CBSM campaign, the first consumers contacted by the marketers are encouraged not only to engage themselves to the project, but also to engage with their friends and family to encourage their social network to also join the campaign. In an environment with a small world social structure, the problem may arise that, since consumers tend to be linked to people like themselves, the members of those social networks will already have been exposed to the marketing message. The difficulty in the social marketing campaign might be engaging with those people who are socially very distant.

The logic of CBSM is similar to that of a contagion. Those consumers infected with the marketing message are encouraged to infect others, but in this case the infection might be a desirable outcome. As with a contagion model, the key vectors might be those customers who cross large social divides to infect entire new communities and where a first response to an outbreak is to limit travel between populations [GKLM06].

Stylized facts about the Winton Wetland

The Winton Wetlands is a restored wetland site, near the regional township of Benalla, in Victoria, Australia. The site has been subjected to a range of land-use and hydrological regimes, since the establishment of agricultural activity in the area. The land in the surrounding catchment was initially developed for agricultural use, and the wetlands were dammed, to form an irrigation reservoir known as Lake Mokoan. After more than three decades as a water-supply reservoir, the dam was decommissioned and the wetlands were drained to restore the site to as close to the original state as possible. The Winton Wetlands are located inside what is considered Victorias High Country Tourism Strategy. A review of the draft of the tourism strategy indicates that the Winton Wetlands would be a strong fit with three of the regions five strategy pillars: cycling, nature-based experiences and cultural heritage [LeaS+99].

The area of the wetlands is approximately 9,000 hectares, of which half consists of the wetland itself, and the remainder consists of a mix between native woodland and altered grassland, which are also home to numerous native fauna and migratory bird populations. The Winton Wetland rehabilitation is the largest wetland restoration project in the southern hemisphere, with the aim of restoring biodiversity values and reintroducing native species within the wetland [Aut12]. There are three communities within a 50 km radius to the wetland; the rural cities of Glenrowan, Benalla and Wangaratta with a population of 963, 13,643 and 26,816 people respectively [oS11].

Under the current plan for the wetlands [LeaS+99], the wetland managers will invest A$7 million initially and then attract a mix of A$25 million in government funding and a further A$25 million in private capital to develop the ecotourism infrastructure in the wetlands. This infrastructure will include a range of accomodation and cafes, as well as an education centre, tree top walk, boardwalks, boat ramps, bike and walking trails and staging for events. The Victorian state government has pledged A$20 million for the wetlands project. The initial local market within 50 kilometers of the wetlands has a population of 67,000, including the three communities mentioned above, and is estimated to provide 140,000 repeat tourist visits per year out of the estimated 340,000 total visits to the wetland per year. Enagagement with the local community around the wetlands is thus a crucial component of the marketing strategy envisaged by the wetlands management. It is this local marketing effort which we will simulate in this paper.

AGENT-BASED MODEL OF A WETLAND ECOTOURISM MARKETING CAMPAIGN

The simulation model examines the effectiveness of small-world networks in coupling across communities. The framework of the model has been described elsewhere [PMBD+13], [PMDB14]. However in that paper tourists shared information about the wetlands with other tourists in a random fashion, whereas herein tourists are now assumed to share information about the wetlands through their fixed social links, which are determined at the start of each simulation.

Social network analyses have shown that typical social networks tend to have a particular structure. Our previous paper had a completely random network structure, but human societies generally to have small world structure where people tend to be linked to other people with whom they share links. The typical small world network structure tends to have lots of short links, where people are tightly connected to those close to them (in terms of geography, family structure, sociodemographics, etc) and only a few long links where people are connected across large social gaps. The social structure of the community is assumed to be a small world. Within each village, the villagers share many social links however across villages the links are rare or non-existent. The next section provides a general description with technical details in the following section.

Overview of the simulation model

There are two main types of agents in the model: tourists and rangers. The tourists - or potential tourists - are located in the surrounding three villages and may choose to visit the wetland as a recreational experience. The rangers interact with the tourists visiting the wetlands, gather resources from the tourists and expend those resources rebuilding and rehabilitating the wetlands.

For simplicity the wetland has only two broad features of interest to tourists: ecology and infrastructure. During a tourist's recreational visit to the wetland area, the tourists interact with the wetland and update their experience based on the levels of ecology and infrastructure which they encounter - modified by the tourist's individual preferences. As tourists interact with the wetland, they consume the ecology and infrastructure of the wetland, which the rangers then repair using resources generated from interactions with the tourists. The alternative tourist activity is labelled the "beach", which represents all other forms of recreation the tourists may engage in. Tourists choose to visit the wetland or the beach based on their past experience and on information about the wetland which they receive through their social network.

The model in this paper features tourists from three townships, with progressively lower levels of participation and stakeholder involvement in the Winton Wetlands. These are the towns of Benalla, Wangaratta and Yarrawonga. Residents in these communities are strongly connected to the people within their own village and sparsely connected to the other villages. Each village is a random small-world network in its own right, but then we break intra-village lengths, and add inter-village links. This reflects network structures within and among communities as detected, for example, by Twitter [BFJ13]. This method is a shortcut to generating networks with community structure directly, as for example, in Sallaberry [SZM13]. These sparse, long links make use of homophily between tourist [Jac08], [Bur27], [MSLC01], [LM54] where tourists are more likely to be linked to tourists in other communities who have similar preferences to their own.

We simulate the transfer of information about the wetland – word of mouth [GLM01] – through the social links which exist within the community around the wetland. The local community of three villages differs according to how much information they initially have about the wetland. The success of the wetland depends on the positive experiences tourists have at the wetland and how effectively positive information about the wetland is communicated through the community. There is a small chance each time step that a tourist will exchange wetland experience information with other tourists through the social network for that tourist. The new value for experience is assumed to be a simple average of the tourist's own experience and the experiences of the tourists to whom the agent has a social link.

The long-term survival of the wetland depends on the revenues raised from ecotourism activities within the wetland. These ecotourism revenues pay for the ecological restoration activities and the infrastructure maintenance conducted by the wetland rangers. The tourism infrastructure within the wetlands is assumed to depreciate over time, so the maintenance of the wetland depends on a constant stream of tourists. These same tourists however also damage the ecology of the wetland and the balance between ecological harm caused by the tourists and revenue raised by the tourists is an important feature of this sort of model.

Technical Details

The model is implemented in Netlogo [Wil99]. Figure 1 shows a screen shot of the environment. The basic model has been described in [PMDB14]. It comprises an environment, a set of agents and a connectivity graph. Values for the parameters are given in Table .

The Environment

The environment consists of the wetlands, the beach and the three communities. Each is represented as a type of patch in Netlogo. No specific activities are modelled in the beach, however, so it is essentially a boundary condition.

The communities are homogeneous, each consisting of Z_v patches, while the beach has Z_b patches. The wetland has Z_w patches, which are initially randomly seeded with a level of infrastructure $Z_{wi}$and a level of ecology Z_{we}. These values are updated continuously throughout the simulation as the agents interact with the path on which they are located. The wetland environment is the heart of the model, and more structure is being continually added, as in the companion paper in this conference [PMBD14].

The Agents

There are two broad types of agents in the model used for this paper: N_r rangers and N_t tourists. Rangers are only located in the wetlands, and tourists are initially only located in the communities. The rangers are further divided into two classes: builders who repair the infrastructure and ecologists who the repair ecology for the patch on which they are located. Each ranger is initially allocated a level of resources, which the ranger will use to repair the infrastructure or ecology - depending on the type of ranger - of the patch on which the ranger is located at the cost of the level of resources which the ranger possesses. At each time step, the ranger roams to an adjacent patch of the wetland and increments the infrastructure or ecology value of the patch at the cost of 1 unit of resources the ranger possesses.

The ranger agents will continue incrementing the infrastructure or ecology of the wetland patches until the patch reaches its maximum level for that quality, or the ranger runs out of resources. The only means for rangers to increase resources is to receive them from a tourist in the wetlands. At any time step when a tourist and a ranger are co-located on a patch of the wetlands, the tourist will make a payment of p resources to the ranger increasing the ranger's resource level. This payment mechanism is intended to mimic the choice of the wetlands managers under the management plan [LeaS+99] that entry fees were not the appropriate mechanism of revenue raising for the wetland but rather fees for particular services would be preferable.

The tourists are initially located in three communities with social networks as described in the next subsection. Each tourist is randomly seeded with a wetland experience which is then updated through the simulation. The initial values for the wetland experience are set at different average levels for the three communities to represent the degree to which the communities are currently integrated with the wetland. The Benalla community is closely tied in with the Winton Wetlands, however the Wangaratta community already has existing water recreation facilities along the Ovens River.

At each time step tourists who are currently not in the wetlands have a 0.6% chance to consider a visit the wetlands. The probability was chosen to mimic the 140,000 repeat visits for the 67,000 residents in the local community of the wetlands under the management plan. However the tourist will only choose a wetland visit if the tourist's experience of the wetland, based on past visits and word-of-mouth, exceeds the expected experience of a visit to all alternative choices of recreation. If the tourist does choose to visit the wetland, the tourist will roam the wetland patches at each time step until the tourist hits the boundary of the wetland and is returned to its community. Thus only a small fraction of the tourist agents are interacting with the wetland at any point in time.

At each time step in the wetland, the tourist updates the wetland experience value. The updated value is a weighted average of the tourist's existing wetland experience, δ_w, and the wetland experience for the current time step, $1 - \delta_w$. Calculating the current time step's experience for the tourist depends on the tourist's preferences for infrastructure and ecology and the levels of infrastructure and ecology for the wetlands patch on which the tourist is located. The preference vector for each tourist is $\bar{e}$ with elements, e_i in the range [0..1] of features in the wetland which they value. The preference vector for each tourist is determined randomly and denotes the relative importance of each feature of the wetland - infrastructure and ecology - in the calculation of the tourist's wetland experience.

The Tourist Social Network

The network of social links between people in each community is dense. But a small number, η_x, of links are broken and connected to an agent in another community. This connection is biased in favour of people, j, k with similar tastes in other communities (homophily) – defined as the Euclidean distance,h_{jk}, between their preference vectors.

Parameter	Symbol	Value
Wetland patches	Z_w	624
Wetland ecology level	Z_{we}	[0..10]
Wetland infrastructure level	Z_{wi}	[0..10]
Village patches	Z_v	1872
Beach patches	Z_b	52
Tourists per village	N_t	50
Wetland experience decay	δ_w	0.9
Tourist preferences	$\bar{e}$	[0..1]
Number of small world links	η_x	[0..10]
Prob of intra-community links	η_l	0.7
Network influence	α	0.5
Tourist payment	p	[30..50]

TABLE I: Model parameters and their values

$$h_{jk} = \sqrt{\sum_i (e_i^{(k)} - e_i^{(j)})^2} \qquad (1)$$

The simulation has three villages of tourists, and each village has N_t tourists. (The representation in Netlogo appears in Figure 1). Each tourist has η_l percent probability of being linked to another tourist in the same village. A small number of social links, η_x within villages were changed to long social cross links across villages.

To form the cross-links, a tourist in one village is selected. The homophily, defined by Eqn 1 is then calculated for each tourist outside the selected tourist's community is computed. The link is then made to the tourist outside the selected tourists's with the greatest homophily.

Simulation dynamics

Each simulation begins with a random assignment of tourists to patches in the villages. Each time step in the simulation is intended to represent a tourist day in the wetlands. At each time step each tourist and each ranger within the wetlands moves to an adjacent patch in the wetlands. When outside the wetland, in the village, each tourist, j, updates his/her estimate of the wetland quality, $q_j(t-1)$ at time $t-1$ according to any changes of opinion by their links in their social network, S according to eqn 2

$$q_j(t) = (1-\alpha)q(t-1) + \alpha \sum_{i \in S} q_i(t-1) \qquad (2)$$

The impact of cross-community links was investigated by running 100 simulations from random starting conditions for different values of the payment from tourist to ranger.

RESULTS FROM THE SIMULATIONS

Figure 1 shows a standard run of the simulation. The green area is the wetland, the brown the three villages, and yellow the beach. The agents represented in the simulation are the rangers located in the wetland and the potential located in the villages with the black lines breaking up the tourists into the three villages. The grey lines between tourists represents the social links between them, which also are the mechanism of diffusion of information within and between the villages.

Figure 1 shows the Netlogo map.

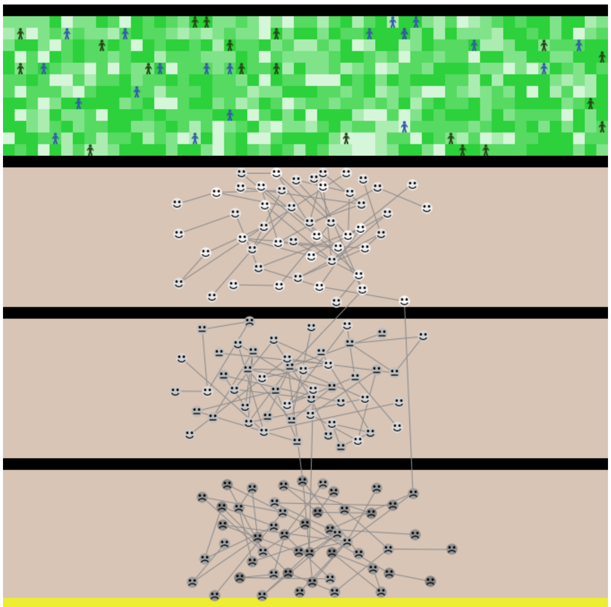

Fig. 1. The World Map in Netlogo

In the simulations we modeled the effect of adding a limited number of long social links - between the three villages. The model is run 100 times for different numbers of long links between the villages, while the values of tourist payments η were allowed to vary between 30 and 50. The success of the wetland in each run is measured by the final level of infrastructure for the simulation, which is a measure of the long-term viability of the wetland.

Figure 2 shows how the park benefits from increasing number of links between communities, where each line represents the average final value of infrastructure varying the number of long links but holding the payment between rangers and tourists constant. The model displays a sharp change of behavior around the value of 40 for the payment.

We found that adding more long links greatly increased the probability of the wetland having a successful CBSM campaign as long as the payment between the rangers and the tourists is at the right level. In other words for CBSM it matters how many links tourists share, but also what types of links.

The model is particularly sensitive to the level of payment made by the tourists as shown by Figure 1. For a payment level of 35 and below, even a high level of social links between communities could not save the wetlands, as the rangers did not receive enough revenues to maintain the attractiveness of the wetlands for ecotourists. For a payment level of 45 and above, the revenues were sufficient to retain tourists without any use of social marketing.

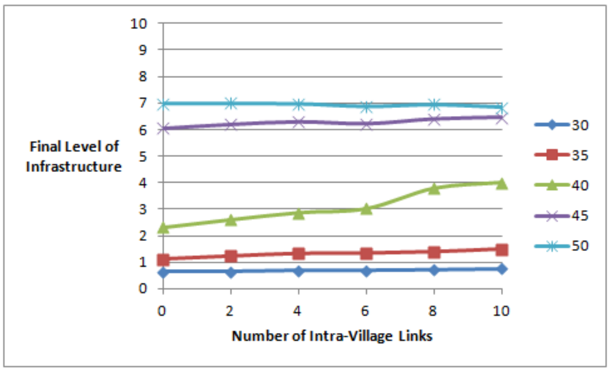

Fig. 2. Plot of Infrastructure Level as a Function of Different Numbers of Inter-Community Links

DISCUSSION AND CONCLUSION

Knowing and correctly using the social structure within the community might be an important feature of a social marketing campaign. A CBSM campaign may not be successful under a small world social structure if the tourists reached by the campaign are highly linked with tourists who have already been communicated with, as all tourists are tightly linked locally. In a small world social structure this feature is likely to be true.

This result suggests that identifying tourists who are likely to have long social links may be a successful strategy for a CBSM campaign, as might identifying tourists who are not like the usual tourist in some feature, as these tourists may allow the marketing campaign to reach out to communities who would not have heard much about the wetland before the campaign.

The sharp difference in behaviour in the simulations around the critical payment parameter value provide a warning about the types of marketing campaigns which might be used by the wetland managers. One possible marketing response to low ecotourist visits would be to cut the price of visits, so raising the volume of ecotourism and perhaps the revenues raised by the wetland. However in the case of ecotourism, an increase in volume of ecotourism is also an increase in damage to the wetland which will have to be repaired. A cut in price may make the financial situation of the wetland far worse with high levels of ecological restoration needed for the wetland with little new revenue. Wetland managers may be far better off using other sorts of marketing campaigns.

AUTHOR BIOGRAPHIES

RODERICK DUNCAN is a senior lecturer in economics and finance at Charles Sturt University. His research interests include international trade, development economics, resource and environmental economics and applied microeconomic analysis.

TERRY BOSSOMAIER is professor of complex systems at Charles Sturt University, specialising in complex systems and their simulation. His work ranges from Agent Based Models of social systems to the study of critical phenomena. He is interested in the behaviour of information theoretic quantities around phase transitions and the prospects of being able to understand herding behaviour or bubbles and crashes. He is the author/editor of five books.

LUISA PEREZ-MUJICA is a doctoral student at Charles Sturt University, but is originally from Mexico. Her project centres around the study of environmental restoration of a wetlands area, combining stakeholder interviews and other inputs with agent based simulation of wetland tourist development.

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