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Easing the adoption of agent-based modelling (ABM) in tourism research

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Agent-based modelling (ABM) is an emerging approach in tourism research. Despite the natural fit between theories of tourism as a complex, interconnected system, and the generative approach supported in ABM, there has been only limited integration within mainstream tourism research. This research letter reports on a recent gathering of tourism ABM researchers to define the main challenges that face the adoption of ABM in tourism research. These include technical, communications, and novelty issues. In response to these challenges, three potential strategies to ease adoption are outlined: education, awareness, and interdisciplinary teams. These findings are framed as a call for increased attention to the fit of ABM within tourism research, and a framework for negotiating constraints to adoption of this technology.

Keywords: agent-based modelling; complexity; tourism systems; methodology

The complex and interconnected economic, social, and environmental systems that drive tourism have long been identified (Faulkner & Russell, 1997; McKercher, 1999). However, it is only recently that complexity science concepts such as heterogeneous and adaptive behaviour, non-linearity, and emergence have been recognised in tourism studies (Baggio, 2008). The tourism system consists of a large number and variety of

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actors who interact with each other within a series of natural and socioeconomic systems and at different spatial and temporal scales. Actors of a given tourism system can range from individuals (tourists, tourism operators, local residents) to institutions (destination, national and regional governments, and policy-makers, tourism lobby groups); from private sector (airlines, hotels) and non-governmental groups (conservation organizations, hotel and tourism associations) to public sector (local, national, regional and international government bodies); and from local (one-off restaurants) to international (hotel chains). The variety of actors and their various levels of interactions contribute to the complexity of the tourism system. Though the tourism system is dynamic and influenced by unpredictable externalities, the models used in tourism are typically linear and deterministic (McKercher, 1999). A variety of computational modelling and simulation approaches have been applied in a tourism context, including system dynamics (Jamal, Borges, & Figueiredo, 2004), cellular automata (Petrov, Lavalle, & Kasanko, 2009), and agent-based modelling (ABM) (Johnson & Sieber, 2009). Despite several calls for these approaches to be better explored (Farrell & Twining-Ward, 2004; Johnson & Sieber, 2010; Milne & Ateljevic, 2001; Nicholls, Amelung, & Student, 2016), progress on this front can at best be characterised as gradual. This contrasts with the relative embrace of complexity science approaches, most notably ABM, in a host of social science domains, including sociology (Macy & Willer, 2002), economics (Tesfatsion & Judd, 2006), urban planning (Batty, 2005), and land use science (Parker, Manson, Janssen, Hoffmann, & Deadman, 2003).

ABM is a useful tool to consider complexity and non-linearity in the tourism system and to explore the impacts of behavioural change on the part of agents. Nicholls et al. (2016) identified four fields of application in tourism research: (1) theory testing; (2) modelling visitor flows; (3) defining and simulating different destination development pathways; and (4) providing input to tourism policy and marketing. To address the gap between tourism studies and the adoption of ABM as a methodology, a workshop was held at Wageningen University in January 2016, representing the most significant clustering of tourism ABM scholars to date. This workshop covered a variety of topics, including approaches to ABM and tourism, validating models, connecting ABM to tourism theory, communicating ABM results, and mainstreaming ABM in tourism research. From this workshop emerged a shared concern over the gaps between the seeming appropriateness and utility of ABM to tourism research, and the lack of traction for the approach within tourism studies in general. We frame this opinion piece based on our conversations at the Wageningen event. We ask, how can the gaps that separate ABM and tourism be mediated or reduced through concrete actions on the part of tourism ABM researchers and the tourism research community? We identify three key challenges for ABM's adoption: (1) technical; (2) communication; and (3) novelty. Not limited to the tourism studies context, these areas of challenge in many ways replicate challenges identified from the early days of mass ABM development, particularly those challenges of communication and technical factors (Parker et al., 2003). Accordingly, we illustrate three ways that these challenges may be overcome: (1) education; (2) awareness; and (3) the formation of interdisciplinary teams. We hope that identifying these constraints and strategies will help establish ABM as a viable research approach to understanding the tourism system's complexity.

Challenges to the adoption of ABM in tourism research

Technical challenges

Several technical phases inherent to the methodology challenge ABM development. Foremost among these is the requirement to transition conceptual understanding to a

computational model. ABM processes take existing knowledge of a system, discretise its various components, flows, behaviours and relationships, and create rules and relationships to describe their interactions. Here agents are computational representations of real-world actors, such as tourists and tourism infrastructure. Each agent can be assigned a unique set of attributes and behaviours, as well as markers to distinguish between different types and roles. Agents interact within an environment (which can be spatially referenced) through pre-defined rules. The behaviour that results at the system level is an emergent property, resulting from micro-scale interactions. To develop this type of representation requires a base level of data about the key components of the system (e.g. tourists, residents, behaviours, industry, landscape) to be integrated into a holistic view of the tourism system. Depending on data availability, the specification of rules of agent interaction can involve many assumptions by the modeller and a high level of abstraction. Testing validity and accuracy of ABM is mostly dependent on data availability, as it requires the comparison of the model results to base level data, calibration of input parameters, and sensitivity analysis. Calibration and validation are stated by Castle and Crooks (2006) as two challenging issues of ABM, which is noted in a lack of consistency in the use of definitions (Gilbert & Troitzsch, 1999; Rykiel, 1996; Sargent, 2013) and lack of consensus as to standard methods for model validation. These often-complicated processes require not only knowledge of the system but also a background in complexity science, statistics, and computer programming. These requirements make ABM's broad adoption more challenging.

Communication challenges

ABM offers a more comprehensive conceptual framework than many other computational approaches. Nonetheless, as has been documented in other fields, ABM users need to communicate methods and results to a tourism audience that is largely unfamiliar with ABM language or modelling process (Waldherr & Wijermans, 2013). For example, the information required by tourism researchers differs from that of ABM programmers. Tourism researchers require information regarding the decisions that actors/agents make, the context and environment those agents act in, and the modelling process. For the ABM community, information on the model's routines is necessary to replicate and/or re-engineer the model. Thus, when presenting ABM to tourism researchers, one should describe model attributes and rules so ABM is not viewed as a 'black-box', but also not overwhelm readers with too many technical details (Pizzitutti, Mena, & Walsh, 2014). Although several approaches to model description have been suggested, no one standardized format is agreed upon by the community (Müller et al., 2013, 2014). A related challenge to communicating ABM studies is how to present results. Tourism journal editors typically favour concise papers with clear and relevant insights. This requirement can be at odds with how ABM generates a range of outcomes and explores processes, rather than providing a single, definitive result. Communications challenges arise from balancing various competing needs; a comprehensive overview of the model's technical details so replication is possible, the capacity of tourism researchers to understand these details, and the conceptual information that is essential to provide a clear model framework. Student, Amelung, and Lamers (2016) provide what the authors consider a good solution to communication challenges by publishing an ABM in a tourism journal where a theoretical description of the functioning of the model is provided, and adding a technical appendix with Grimm's ODD – Overview, Design concepts and Details (Grimm et al., 2010) model description framework which focuses on technical aspects that allow better understanding and replication of an ABM (e.g. agents attributes, scales, behavioural rules, thresholds, scheduling).

Novel approaches in the tourism research community

The introduction of ABM in any field must overcome low levels of awareness compared with existing approaches. First, awareness of ABM within tourism has been hindered by several key ABM tourism studies being published in non-tourism venues, such as planning (Johnson & Sieber, 2011a, 2011b), climate change (Pons-Pons, Johnson, Rosas-Casals, Sureda, & Jover, 2012), geography (Soboll & Schmude, 2011), and modelling/information science (Balbi, Giupponi, Perez, & Alberti, 2013; Pons, Johnson, Rosas-Casals, & Jover, 2014). This diffuse publication strategy has led to a lack of core literature on tourism ABM being presented in tourism journals, though more recently Nicholls et al. (2016) compiled much of that literature. Second, there is a lack of tradition in computational methods in tourism research, and so the absence of an already existing canon into which ABM can be placed. Third, ABM must overcome the inertia generated by a history of traditional tourism research methods (quantitative surveys, qualitative interviews, etc.). ABM needs to demonstrate its relevance to the tourism research suite of methods; however, this is further challenged by a lack of appropriate reviewers for tourism ABM studies, creating a difficult task for journal editors. Fourth, there is a lack of best practices available that can provide 'how to' guides with insightful lessons and experiences to potential researchers. The absence of such material is typical of the pioneering phase that tourism ABM is currently in. Overall, ABM needs to 'prove itself' as an approach that would both integrate well with tourism topics and hold value as an investigative method.

Strategies to ease the adoption of ABM in tourism

The above challenges present notable barriers to the further adoption of ABM within tourism research. Despite the durability of these challenges, we present three strategies that may help ease the adoption of ABM in tourism: (1) increased education and instruction; (2) increased awareness; and (3) creation of interdisciplinary research teams.

Education

As a comparably new approach, there is a strong need for improved instruction in not only ABM, but in the underlying complexity science and systems thinking foundations in tourism. Even in a curriculum with a strong focus on qualitative and quantitative methods, this would rarely include complexity-embracing modelling techniques, and in particular ABM. As ABM toolkits continue to develop, they become viable introductory tools for senior-level courses. This does not mean that students should be expected to create fully validated and realistic models of a particular tourism system, but rather that tools exist to support the construction of 'toy' models with which to experiment with core tourism dynamics (visitor–host relationships, destination overcrowding, the impact of marketing on arrivals, the effects of particular policies, etc.), stressing their exploratory potential for creating different scenarios. Technologies supporting access to ABM have progressed rapidly in recent years; several existing software packages aim to ease this constraint. Though often limited compared to programming libraries, user-friendly packages are maturing rapidly, providing a scaffold for new ABM users. One example of an ABM programming library and education curriculum is the Northwestern University Center for Connected Learning and Computer-Based Modeling (CCL) (http://ccl.northwestern.edu/), which provides extensive ABM examples. Nikolai and Madey (2009) also provide an overview of many ABM platforms. Despite the availability of tools to support instruction and

experimentation with ABM, there is a notable lack of tourism-specific curriculum materials or sample models. Creation of this content would support increasing awareness of ABM and its potential role within tourism research and practice.

Awareness

Wider-scale recognition of the value of ABM to tourism researchers would be bolstered by a concerted effort on the part of ABM proponents to demonstrate its utility through publication in established tourism journals (e.g. via a special issue on the topic) and at key tourism conferences. Recent publications in three different tourism journals (Boavida-Portugal, Cardoso Ferreira, & Rocha, 2015; Bonzanigo, Giupponi, & Balbi, 2016; Nicholls et al., 2016; Student et al., 2016) and a chapter in a quantitative tourism methods book (Baggio, 2011) help introduce ABM to tourism researchers and indicate that ABM is transitioning into the tourism domain.

The accessibility of ABM to interested tourism researchers would also be greatly improved by a central repository of basic knowledge and sample models tuned to tourism applications. Many starting with ABM in tourism research will face similar questions: is ABM a useful tool to answer the research question; what modelling platform to use; where to set system boundaries; how to involve stakeholders; how to validate the model? Answers depend on the individual context, but it helps to know what has previously been attempted and found to work. Experienced researchers have hard-won knowledge of these issues, but most of it is tacit. A 'first-aid-kit' for ABM and tourism would help make some of this knowledge explicit, keeping users from needlessly replicating past efforts, instead accelerating advances in the field. Although such a resource specific to tourism researchers still needs to be developed, Macal and North (2006), Castle and Crooks (2006), and Macal (2016) give general information of how to get started using ABM and describe when to use it and how to build a model with details such as agent attributes, behaviour rules, agent and model processes. To compare and select a specific modelling platform, Balbi and Giupponi (2010) provide an overview of available software packages, their applications to different research objects and the required programming skill-level. A first-aid kit developed for tourism researchers should include examples of previous tourism ABM models (e.g. Nicholls et al., 2016), including basic tourism relevant mechanisms (e.g. flow dispersal, preference decision-making) and model process descriptions, giving an overview of the problems that are already known by the 'tourism ABM community' and possible solutions or paths to address them. However, framing these paths can be challenging, as there is no universal solution for specific problems such as 'how many parameters should the model have?', 'how many agents?', and 'how should one translate tourism theories into programmable computer behaviours?'. The first-aid kit should focus on framing a general approach to problem solving and model construction, rather than context-specific support. For example, Macal (2016) and García-Magariño (2015) address the need to establish a common vocabulary for dealing with ABM, and to establish process guidelines for developing ABM.

Interdisciplinary teams

In most cases, developing an agent-based model requires advanced knowledge of the research subject and the key relevant scientific disciplines, in addition to a range of skills, most notably with respect to modelling, communication, and managing stakeholder participation. These requirements will only become stricter as ABM matures as a valid

approach to tourism research and expectations increase. It is virtually impossible for any individual to master all the knowledge and skills required. Forming interdisciplinary teams of tourism researchers, process managers, disciplinary specialists, programmers, and even industry or community stakeholders is one solution. The learning curve of developing a workable form of communication within the team is often steep, but benefits far outweigh costs. The most notable ABM applications in tourism were all products of interdisciplinary teams. A prominent example is the Canada–Alps–Andorra project (Scott et al., 2015), featuring an interdisciplinary team combining knowledge of tourism, ABM, snow modelling, and geospatial analysis to provide a body of research on climate change impacts. Synergies can be realized not only within project teams, but also among different teams. Exchanges during the Wageningen workshop, for example, enriched participants' understanding of many aspects of the ABM-tourism nexus, including theoretical insights, methodological possibilities, challenges, and practical solutions to recurring problems. Community development is crucial, if only as a kind of interdisciplinary team formation at a meta-level.

The way forward for ABM in tourism research

The goal of this letter is to frame the current role of ABM in tourism research as a discussion between adoption challenges and possible solutions. The main challenges to adoption – technical, communication, and novelty – are not unique to ABM and tourism, but are found in the introduction of many technologies into various disciplines (Parker et al., 2003; Rogers, 2010). Despite the often durable nature of technology adoption challenges, the three strategies presented here all provide ways to advance better integration of ABM with tourism research. We collectively believe that ABM has much to offer tourism, and indeed the tourism research community has been quite forward looking in its historical investigation and adoption of new techniques, particularly in exploring complexity and systems approaches from a theoretical perspective.

Disclosure statement

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