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Introduction

The fast growth of electronic word-of-mouth (eWOM) have profoundly shaped a considerable proportion of tourists' destination choices/expectations as well as transformed many destinations' development plans (Chu and Kim 2011, Jalilvand et al. 2012). In order to fully understand and optimize the significant influences from eWOM, empirical studies have adopted correlational analyses to identify the interrelationships between eWOM, destination image, as well as tourist attitude and behaviors (i.e., ravel intention, satisfaction, loyalty, etc.) (Jalilvand et al. 2012, Setiawan, Troena, and Armanu 2013, Wang 2015), yet rarely are studies identifying the dynamics of how destination image and tourist attitudinal/behavioral changes given the accumulative influences from eWOM over time. Such *evolutionary* analysis of tourism patterns is lacking yet of great value for travel destinations to reveal useful service management and marketing strategies in order to optimize the eWOM effect on destination image and visits.

Furthermore, the correlational models can neither identify how the online tourist-tourist *interactions* and tourist-destination *interactions* will influence the global tourist visits distribution across destinations, as well as the evolvement of destination attributes. Many factors should be considered in such an exploration, for instance, different tourists vary in their influences on other tourists' decisions through eWOM and also vary in the level of influences they receive from eWOM; and a destination marketing strategy may also have varied influences on different potential tourists. Such variations jointly influence the global travel patterns and hence should be taken into account (Cheng and Zhou 2010). However, the complexity of including all these features in a correlational model would overwhelm the model. Such interactive procedure consequently has been treated like a "black box" given the lack of tool to analyze such complex dynamics.

The current study thereby aims to unravel the complexity of tourist-destination interactions and predict the future tourist travel and destination evolvement patterns within the context of fast growing eWOM influences. Accordingly, possible marketing or management strategies are experimented with simulations to test their effectiveness in facilitating tourist travel decisions and destination development.

Conceptual Contribution

It is complex yet significant meaning to investigate the macro-level patterns of tourism system that emerge from simple agents and interaction rules yet cannot be observed within a short period or captured by static statistical analyses. Agent-based Modeling (ABM) is hence introduced as a useful tool that could determine the behavior of autonomous agents, whose interaction with other agents, and the environment produces the behavior of the system as a whole (Bonabeau 2002, Perez-Mujica, Duncan, and Bossomaier 2014). ABMs are essentially computational models built to simulate agents' (tourists) behaviors based on formal assumptions and learning algorithms (Gilbert and Terna 2000). Its uniqueness is that it not only provides the outcome of tourist interactions and tourist-destination interactions, but also reveals the dynamics of the interaction process itself without sacrificing the rigor of formal modeling (Nelson and Winter 2002). ABMs also visualize the emergent patterns of complex tourism system from individual tourist travel behaviors and interactions with other tourists and environment, which is otherwise not observable using other statistical methods (Kornhauser, Rand, and Wilensky 2007).

Practically, ABM simulations allow destination marketing and management to evaluate the changes of tourism demand and tourist satisfaction along with their adoption of new marketing/management strategies, without taking the high risks and actually investing considerable resources to applying those strategies in realities and preparing for possible failures.

With regards to existing research on eWOM, there are in general three aspects of focus: the communicator's characteristics, the receiver's characteristics, and the communication procedure and contents (Luo and Zhong 2015, Hennig-Thurau et al. 2004, Cheung, Lee, and Rabjohn 2008). The studies that investigated the communication procedure either primarily investigate social media communication and its strength of influence on individual travel decision-making (Rong et al. 2012, Luo and Zhong 2015), or explored the connections between service suppliers as in collaborative marketing to tourists (Ying, Norman, and Zhou 2014). The current study adds to the existing body of work on eWOM by taking both destinations (service providers) and tourists into account and investigates their multi-party interactive patterns, with computational modeling and visual simulations.

Another contribution of this study is the integration of Kano et al's (1984) Three-factor Theory of service-satisfaction structure with the ABM approach. The Three-factor Theory has been widely applied in tourism destination studies to identify three categories of destination attributes that have varied influences on tourist satisfaction: basic, performance, and excitement attributes (Alegre and Garau 2011, Fallon and Schofield 2006, Fuchs and Weiermair 2004). While basic attributes (i.e., information access, price, budget, lodging) contribute the most to tourist dissatisfaction, excitement attributes (i.e., socializing with other tourists, doing sports) contribute more to satisfaction and performance attributes (i.e., climate, cultural activities) contribute equally to both. In addition to the plethora of studies on this topic, however, a comprehensive perspective is in need to provide a more accurate understanding of how tourists evaluate their satisfaction about destinations. It should be noted that when tourists evaluate their satisfaction/dissatisfaction about a destination, they generally evaluate the destination against the other destinations that they have previously visited. To better understand the influence of such simultaneous multi-destination attribute comparisons on tourist satisfaction, the current study constructed an ABM computational simulation model based on the three-factor theory, to predict how the relative performances of a destination among the global destinations on the three categories of attributes may impose different influences on destination evolvement and tourist satisfaction.

There has been increasing interest in applying ABMs to identify global patterns out of complex individual behaviors. Several environmental science studies have applied ABM to evaluate destination management strategies as adapted to weather and tourism demand changes (Balbi et al. 2013, Du, Guo, and Jin 2015). Some other studies tapped on the topic of destination expansion and growth. For example, Ma, Weng, and Yu (2015) examined the effectiveness of different destination expansion strategies given the contradicting influences from scale economy and market size. A growing trend is that scholars tend to adopt ABM modeling for social marketing purposes. Perez-Mujica, Duncan, and Bossomaier (2014) for instance simulated local residents' possible collaborations in promoting destination tourism development. Similarly, Baggio and Cooper (2010) simulated the social network among stakeholders of an Italy town, which potentially facilitate future collaborative promotion of local tourism. Therefore, the global investigation of the tourist-destination and tourist-tourist interactive effects on tourist travel behavior and destination evolvement is still a less-explored yet promising area, where ABM model provides a proper fit for such global investigations.

Methods

The current study constructs the tourist-destination simulation model based on multi-agents simulation platform of Netlogo (Wilensky 1999), which allows the exploration of both the micro-level tourist choice behavior and the macro-level patterns (tourist visits distribution across destinations, tourist evaluations of different destinations, tourist general travel satisfaction, overall trend of eWOM share and compliance, etc.) emerging from tourist-destination and tourist-tourist interactions.

In the simulation model, tourists are "agents" who receive destination-related information from both destination mass media marketing and other tourists' word of mouths, which together with tourists' previous travel experiences to the destination influence their future visit intention to that destination. The agents may also provide further feedback to other tourists regarding their evaluations of destinations after their visits. Therefore, the travel decision-making procedure is the cycle of several fundamental steps: (1) destination information gathering, (2) destination information evaluation against individual travel preference, (3) actual visit and on-site evaluation of the destination, (4) after-visit share of destination evaluation with other tourists. It should be noted that, tourists are all autonomous and heterogeneous agents, each of whom may have difference choices regarding the sources of information to gather destination information from, varied expectations about destination attributes, different decisions regarding whether or not travelling to a destination, different preferences regarding whether travel repeatedly to a same destination or always travel to a new one, as well as the varied likelihood to share their destination experience with other potential tourists. Different combinations and proportions of heterogeneous tourist agents (i.e., few tourists share and most tourists follow or most tourists share and few tourists follow) are thereby experimented in the simulation model to reveal the variations of macro-level destination development patterns as premised on tourist market features.

The action rules for the tourists in general is that, they have varied probabilities in terms of whether choosing a destination to maximize the satisfaction of their perceived most important destination attributes. Therefore, they would either choose the destinations being rated the highest by previous visitors on the attributes they care the most about (only applicable to tourists who at a great probability tend to follow others' recommendations), or simply search in their memory the destinations they visited, or randomly pick a destination to travel to. Another assumption is the asymmetric contribution of three types of destination attributes to tourist satisfaction according to Three-factor Theory, that is basic attributes lead to more satisfaction, excitement attributes lead to greater dissatisfaction, while performance attributes contribute equally to both. Also, premised on Tourism Area Life Cycle (Butler 2006), with the temporary tourist visits exceeding the carrying capacity of the visited destination, those tourist visit that destination at the time will experience a deduction of travel satisfaction and also will decrease their evaluation rating of that destination. In terms of the probability to share/follow, the probability to share and follow increase for the most satisfied and dissatisfied tourists. Given the pre-set proportion of sharers vs. followers, sharers would add their satisfaction values to the destination evaluation, and followers would use the destination evaluation rating as the reference to make the destination choice. Importantly, sharers also have greater bearings on destination evaluation score, which is taken into account by weighting each tourist's destination evaluation when it is added to the total destination evaluation.

The tourist parameters are initialized following the general destination and tourist market status quo as summarized from a meta-analysis of destination and eWOM literature in recent five

years. The key parameters of tourists and destinations, as well as their initialization are summarized in Table 1.

Table 1. Key Parameter Summary

Parameter	Meaning	Initial values
Tourist parameter		
exp_uti_{basic}	Tourist expectation of destination performance on basic attributes	Randomly generated from [0,1]
$exp\_uti_{performance}$	Tourist expectation of destination performance on performance attributes	Randomly generated from [0,1]
$exp\_uti_{excitement}$	Tourist expectation of destination performance on excitement attributes	Randomly generated from [0,1]
sat	Tourist satisfaction about a destination after visits	0
p_{share}	Individual probability to share feedback with others after destination visits	Randomly generated from [0,1]
p_{follow}	Individual probability to follow with others' destination recommendations	Randomly generated from [0,1]
$p_{revisit}$	Individual probability to revisit a previously visited destination as opposed to explore new destinations	Randomly generated from [0,1]
p_{travel}	Individual probability to travel opposed to staying at home at each time tick	Randomly generated from [0,1]
memo	Memory record of the destinations that an individual has travelled to	0
freq	Total number of individual travel times	Random 100
Destination parameters		
uti_{basic}	Destination actual performance on basic attributes	Randomly generated from [0,1]
$uti_{performance}$	Destination actual performance on performance attributes	Randomly generated from [0,1]
$uti_{excitement}$	Destination actual performance on excitement attributes	Randomly generated from [0,1]
temp_num	The number of visitors received in a destination at the	0

	same time	
total_num	The total number of visitors received by a destination over time	0
cap	The maximum number of tourists allowed in a destination without compromising the environmental quality of the destination and the visitor satisfaction.	Randomly generated from [1, total number of tourists]
eval	Accumulative satisfaction of all visitors about the destination	0

With regards to the assumptions about tourism destinations, different destination are the "patches" with varied destination features and capacity levels, which are located at a random distance from tourists (see Graph 1 for initialization status and pattern after 100 ticks). Based on the widely acknowledged Three-factor theory, the destination features are categorized into three types: basic attributes, performance attributes, and excitement attributes. The destinations should vary in terms of their respective values on the three attribute types. Therefore, given a lack of empirical data documenting the global distribution of attribute values across destinations, this study hence experimented several possible scenarios and distributions and compare for the conclusion variations., i.e., uniform distribution, normal distribution, and skewed normal distribution, etc.. The similar scenario experimentation has been conducted to examine the variation of carrying capacity distribution among destinations on tourist behavior and destination development. To reflect the realities of destination evolvement, the Tourism Area Life Cyle has been embedded in the model so that when a destination receives tourists more than its maximum capacity level, the utility of the destination would decline until the capacity level is optimized or the tourist visits fall below the capacity level. The three types of destination attributes and carrying capacity were initialized to follow a normal distribution whereas the number of tourist visits at each time tick and total evaluation rating by tourists are set as 0 for initial values, as they will accumulate with visits over time. Each simulation model is run for several times to exclude the possible influences from random factors.

**Graph 1.** The initialization and 100th tick pattern of destinations and tourists
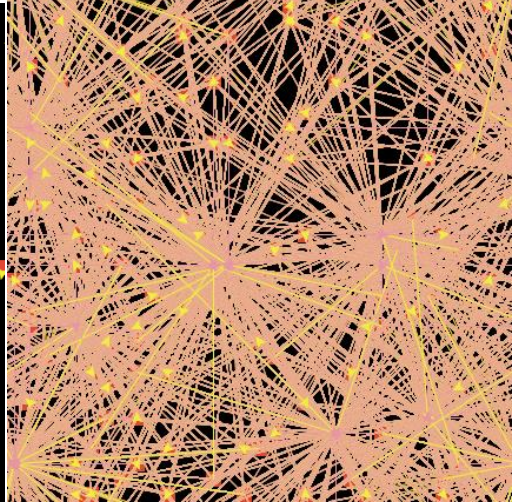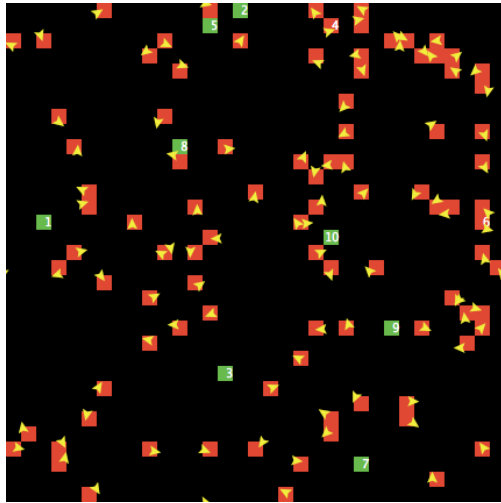
Each simulation model is run for several times to exclude the possible influences from random factors. The destination and tourist number have also been varied (i.e., 20 destinations, 1000 tourists, etc.) to validate the observation reliability.

Key Findings

The visual pattern of tourist visits is shown in Graph 1, where on average slightly over than half of the destinations are crowded at each time tick (whose temporary tourist visits are more than its carrying capacity). Some general patterns of tourist visits are revealed, including: (1) the temporary tourist visits for all the destinations fluctuate around its carrying capacity level, and destinations with higher level of carrying capacity in general attracts more tourists to visit (Graph 2), hence it suggests *the necessity for destinations to optimize their management strategies for enlarged carrying capacities*. The increase of carrying capacity is experimented for randomly chosen destinations and the increase in tourist visits is indeed observed; (2*) One destination is always dominant in terms of temporary tourist visits and tourist evaluations*, despite how many destinations are simulated, and regardless of the probability for tourists to share or follow destination evaluations (Graph 3); (3) The higher the probability of following eWOM destination recommendations, the greater overall evaluations of all destinations and travel satisfaction, and on average the temporary visits for destinations are greater; yet regarding the probability of sharing eWOM destination evaluations, the higher the probability to share, the lower overall destination evaluations and travel satisfaction among tourists, and the less average visits to destination. Reasonably, the evaluation differences between destinations are also enlarged, given that more people with varied levels of evaluative criteria start to share their destination evaluations. Therefore, essentially it is *the probability to follow eWOMs* that should be promoted to enhance destination attractiveness, while enhancing probability of share on the other hand would enhance the discrepancy between destinations in visits, as well as reduce the overall destination attractiveness and tourist satisfaction (Graph 4).
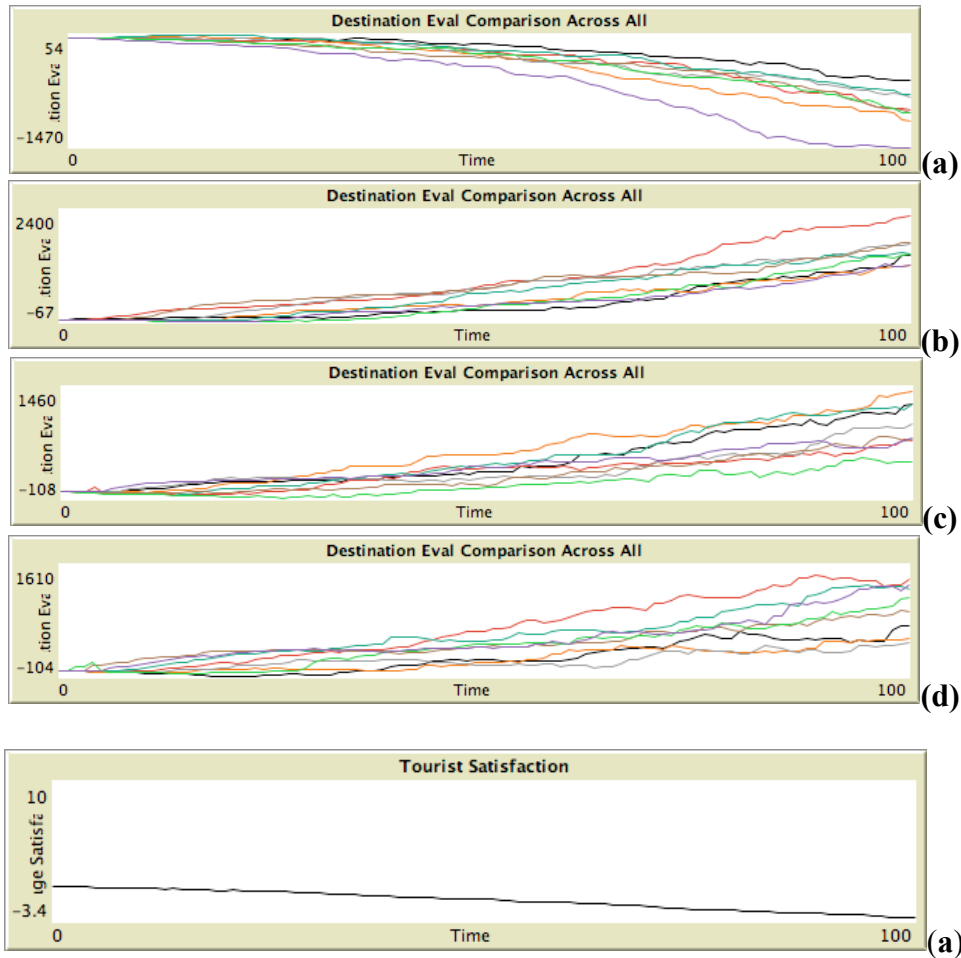
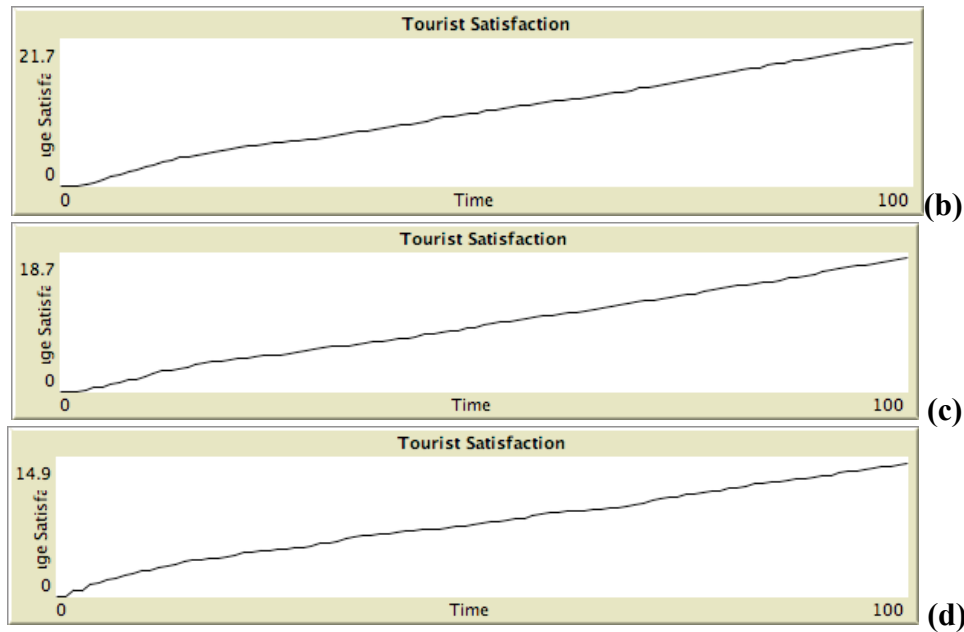**Graph 2.** Destination Visit Comparison (High vs. Low Carrying Capacity)
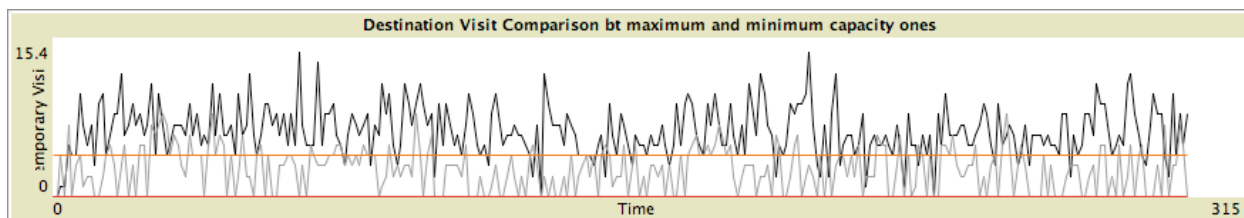
**Graph 3.** Destination Visit and Evaluation Comparison (1000 ticks)
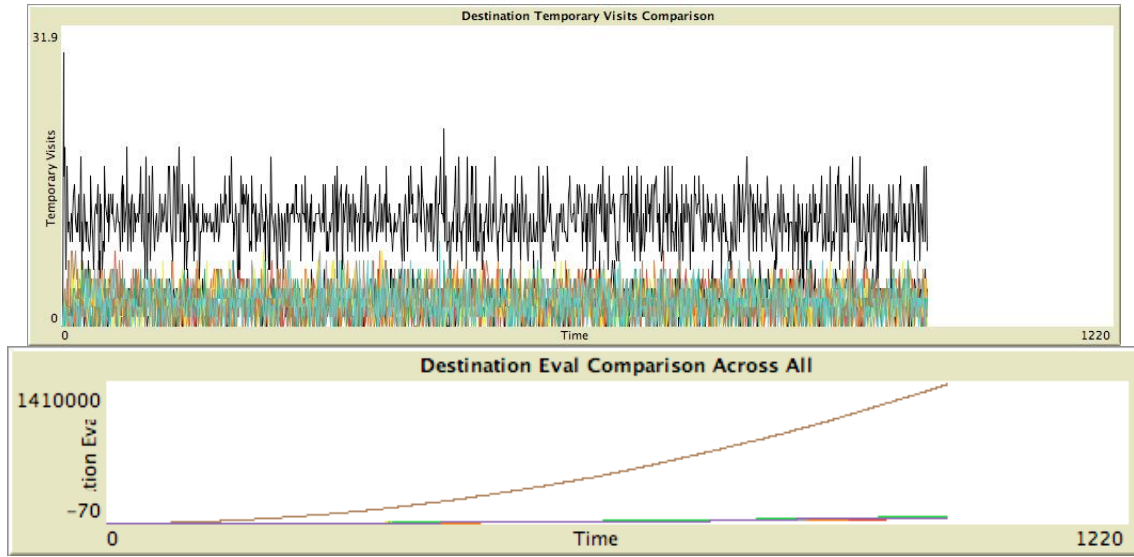
Graph 4. Destination Evaluation and Tourist Satisfaction Comparison (100 ticks) (a: low share & low follow; b: low share high follow; c: high share & low follow; d: high share & high follow)

(b)

(c)

(d)

The relative importance of three destination attribute types in determining destination evaluation and tourist visits is also observed, and it was found that the basic attributes lead to greater differences in destination evaluation and tourist visits, whereas the excitement attributes cause the minimal differences (Graph 5). Therefore, destinations ought to prioritize the development of basic attributes, followed by performance attributes, and lastly the excitement attributes, in order to optimize the investment of limited budget and resources on the attributes that most greatly enhance tourist visits and significantly distinguish the destination from other competitors.

Graph 5. Destination Visit Comparison between (Best vs. Worse Attribute Performances) (a: Basic Attributes; b: Performance Attributes; c: Excitement Attributes)

(a)

(b)

(c)
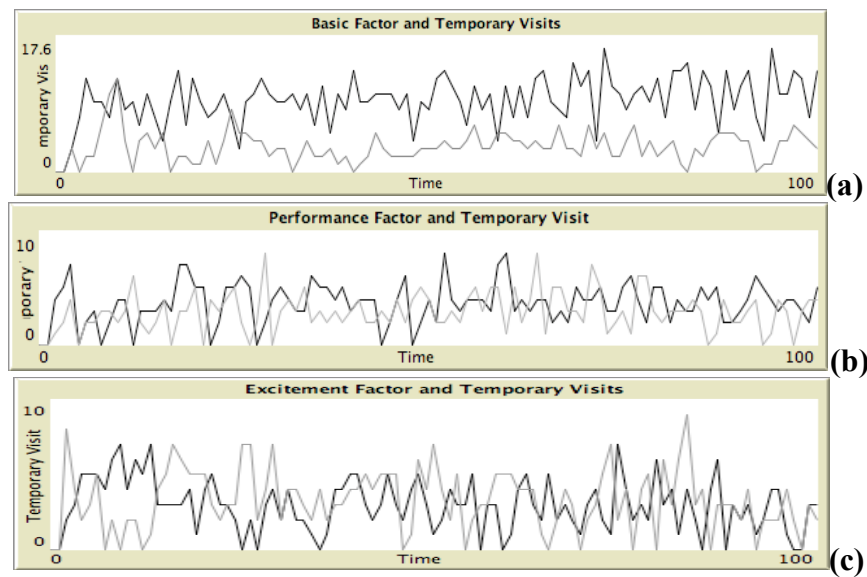
One increasingly popular destination-marketing strategy has been experimented to examine its effectiveness in the complex tourism system. The trend is for tourism businesses to

provide exceptional services to people who provide most shares on social media, with hope that the significant influences these people have via eWOM would spread the positive image of the businesses fast and raise the attractiveness of the businesses among the general public. However, when the current study involve such strategy into the simulation mode, it was found that with such special treatments to active eWOM providers, the overall tourist satisfaction and overall evaluations of destinations become lower, as well as the probability to follow. It is probably because that people gradually experience dissatisfaction travelling to the most recommended destinations and perceive eWOM as non-trustworthy as a result. Hence there will be a deduction of probability to follow as opposed to the increasing interest to share (Graph 6).

Graph 6. Probability to Share vs. Follow
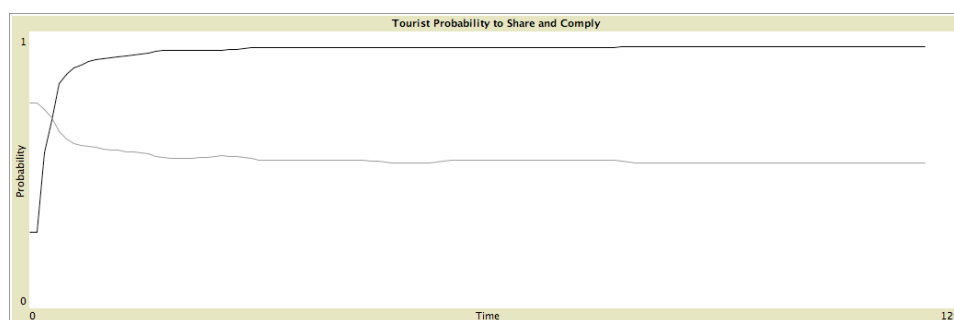
Implications and Practical Applications

The current study contributes by introducing the Agent-based Modeling into the exploration of destination evolvement as a result of tourist-destination interactions through eWOMs. The visual and graphical outputs generated from ABM are macro-level patterns about global tourism system that otherwise cannot be observable or hard to be analyzed given the data inaccessibility for the scope of problem. Practically, the marketing/management strategies properly fit the predictive macro-level patterns can be hereby recommended to the marketing/management bodies to enlarge their probability of success. For instance, the marketing strategy that provides special treatment to eWOM intensive providers may not be sustainable to generate increased tourist visits and positive evaluation in the long run; the importance of enhancing carrying capacity to destination evaluation is necessary, regardless of the destination's performance on other attributes; destinations should manage their attributes in order of basic attributes, followed by performance attributes, and lastly the excitement attributes, in order to optimize their investment resources and maximum the tourist visits.

Future Studies should further investigate the interactive evolvement between DMOs, resident community, and tourists via eWOMs (Arsal et al. 2009). Another possible topic to explore is how DMOs' share of information through online forums interacts with tourists' eWOMs and influences tourist attitude and behavior (Lange-Faria and Elliot 2012). ABM as a promising tool to identify patterns in the complex tourism system should be applied in a broader range of topics in tourism field.

Some possible improvements of current ABM model include: (1) Some possible variation in real life could be added, such as the possibility for tourists to switch the importance allocated to different destination attributes when they evaluate a destination; (2) The relative influence of destination marketing eWOM as compared to neutral eWOM by other tourists could be further investigated as an extension of the current ABM model; (3) the model simulations could be

further tested with the empirical data from a region with several competing destinations for verification and evaluation of that region's marketing/management strategies.

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