Knowledge transfer in smart tourism destinations: analyzing the effects of a network structure

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Abstract

In academia as well in the industry there is currently an increasing interest in the concept of smart tourism destination. Specifically, it has been widely underlined the relevant role that ICTs, Internet of Things and Cloud Computing exert in providing instruments and platforms that can facilitate the dissemination of information and knowledge among stakeholders, thus enhancing innovation and destination competitiveness. Despite that, not much research exists that aims at understanding the processes of information and knowledge transfer, sharing, and conversion in smart tourism destinations. This paper contributes to deepen the scientific debate around this topic by applying a network analytic approach to the case of three tourism destinations. Findings reveal that effective knowledge-based destination management studies should consider both the virtual and the real components of the network structure of the destination. Contributions to the body of knowledge and managerial implications are discussed and suggestions for further research are given.

Keywords: smart tourism destinations, knowledge transfer, epidemic diffusion models, network analysis, digital business ecosystem

1 Introduction

In the last decades, Information and Communication Technologies (ICTs) have radically and unforeseeably changed our society as a whole, with travel and tourism being one of the sector that has been most transformed, especially since the Internet of Things emerged (Atzori, Iera, & Morabito, 2010), making available multidimensional set of data, known as Big Data. The progress to a higher socialization of ICTs, the advent of Internet of Things and Cloud Computing have now made much more relevant (and fashionable) the recent concept of digital business ecosystems (Nachira, Dini, Nicolai, Le Louarn, & Rivera Lèon, 2007) and have provided the venue for the emergence of the new concept of smart city (Giffinger et al., 2007). Based on this strand of research, the idea of tourism destinations as digital business ecosystems (Baggio & Del Chiappa, 2014a) in search for strategies to become smarter (Buhalis & Amaranggana, 2014) is rapidly emerging in literature. The digital revolution and the convergence of information and communication technologies have been igniting the development of new communication grids, thus challenging the traditional technologic scenarios and rendering smart cities and smart tourism destinations the basis for urban and tourism competitiveness (Batty et al. 2012; Branchi, Fernàndez-Valdivielso and Matias, 2014) and sustainability (Morelli et al., 2013).

In an increasingly globalized and extremely dynamic environment, innovation is the key element for cities and tourism destinations to be competitive. Organizations of any type should consider location and spatial information as a common goods, thus meaning that they should do as much as they can to make it available within the network thus stimulating innovation (Roche, Nabian, Kloeckl, & Ratti, 2012), both at a collective and individual level. Hence, sensing, analyzing, and integrating information and knowledge can be considered as a core aspect of any smart cities or smart tourism destinations (Su, Li, & Fu, 2011). Despite that, academic research has sparingly examined and discussed how this process can occur and how it can be assessed, measured and predicted (Baggio & Cooper, 2010). This paper uses and mixes epidemic diffusion models and other network analytic methods applying them to the case of three Italian tourism destinations, and considering the enabling role that ICTs can exert in this process (Roche et al., 2012). The aims are twofold. First, we attempt at establishing the extent to which the technological association has affected the structural configuration of a tourism system. Second, we examine the nature of networks and how their analysis can contribute to understanding the processes of knowledge transfer among stakeholders. To this purpose, we extend the analysis discussed in the preliminary work by Baggio and Del Chiappa (2014b) (presented at ENTER2014, 21st International Conference on Information Technology and Travel & Tourism, January 21-24, 2014 – Dublin) in order to show and estimate, by simulation, how an increase in the virtual connectivity improves the diffusion process within a tourism destination. Specifically, the study employs a spectral analysis of the networks and uses it to assess the extent to which the digital ecosystem is able to speed up the diffusion process. A simulation shows how important the effect of the digital component is on the whole ecosystem behavior.

2 Theoretical background

A smart city can be defined as "a city in which ICT is merged with traditional infrastructures, coordinated and integrated using new digital technologies" (Batty, Fosca, Bazzani, & Ouzounis, 2012, p. 481); its main goals are "developing a new understanding of urban problems, effective and feasible way too coordinate urban technologies; models and methods for using urban data across spatial and temporal scales; developing new technologies for communication and dissemination; developing new forms of urban governance and organization; defining critical problems relating to cities, transport, and energy; and identifying risk, uncertainty and hazards in the smart city" (Batty et al., p. 481). According to Kmninos, Pallot, and Schaffers (2013) the main pillars of smartness for any city are human capital, infrastructure, and information (Komninos, Pallot, & Schaffers, 2013). Similarly, Nam and Pardo (2011) consider technology, people, and institution as being pivotal factors for smart cities. Broadly speaking, smart cities are cities well performing in the following six matters: smart economy, smart people, smart mobility, smart environment, smart living and smart governance (Giffinger et al., 2007, p. 10; Lombardi, Giordano, Farouh, & Yousef, 2011). In particular, the latter requires a thorough consideration of stakeholders' participation in decision-making, public and social services, transparency, and political strategies and perspectives (Giffinger et al., 2007, p. 10). In the last few years, the idea of ICTs and social media as being tools able to play an important role in the destination governance processes and in the processes of stakeholders' involvement and engagement has been attracting huge attention from both the industry and academia (e.g. Fuchs, 2006; Munar, 2012; Presenza, Micera, Splendiani, & Del Chiappa, 2014; Sigala and Marinidis, 2012), thus generating the concept of "e-governance or "e-democracy" (Giffinger et al., 2007, p. 10). According to Nam and Pardo (2012), learning and knowledge have central importance for smart cities and smart tourism destinations, with knowledge management also being one of the main dimension of the destination governance (Ruhanen, Scott, Ritchie, & Tkaczynski, 2010).

The concept of smart tourism destination arises from that of smart city. Actually, the concept itself may be considered still emerging and the work of conceptualizing and defining it is still in progress. In contextualizing the concept of digital business ecosystem (Nachira, 2002) to the tourism sector, Baggio and Del Chiappa (2014a) defined a tourism destination as a networked system of stakeholders delivering services to tourists, complemented by a technological infrastructure aimed at creating a digital environment which supports cooperation, knowledge sharing, and open innovation. In such a context, the physical and virtual components are structurally strongly coupled and co-evolve forming a single system thus meaning that all modifications, changes or perturbations originating in one of them rapidly propagate to the whole system (Baggio & Del Chiappa, 2014a). Tourism researchers concur that effective and efficient information and knowledge exchanges, sharing, and development among all the stakeholders involved within a destination network is crucial for tourism competitiveness (Otto & Ritchie, 1996; Argote & Ingram, 2000; Komninos, 2008). In such a context, ICTs, information systems, and social media can be considered as important coordination mechanisms (Bregoli & Del Chiappa, 2013) that allow information and knowledge to flow more easily across the destination, more contextual data to be transmitted, and opinions to be shared (Breukel & Go, 2009: 188). Moreover, the idea that ICTs are among the variables that might influence knowledge sharing the most is well established also in strategic management literature (Yang, 2010). This view is coherent with what Buhalis and Amaranggana (2014, p. 557) have recently noticed when stating that "bringing smartness into Tourism Destination requires dynamically interconnecting stakeholders through a technological platform on which information relating to tourism activities could be exchange instantly". The top priorities of any smart tourism destinations can be analyzed by adopting a demand-side or a supply-side perspective. That means: enhancing the tourist's travel experience, providing intelligent platforms to gather and distribute information within local stakeholders (Nam and Pardo, 2011), facilitating efficient and effective allocation of tourism resources, integrating tourism suppliers to ensure that the benefits from tourism are equally distributed to local society (Buhalis and Amaranggana, 2014). To sum up, and based on Edvinsson (2006)'s concept of learning city, it can be argued that smart tourisms destination should purposefully be designed and managed with the objective to encourage the nurturing of knowledge (Roche & Rajabifard, 2012) thus contributing to the shaping and operating of an open innovation ecosystem (Schaffers et al., 2011). In other words, a smart tourism destination can be considered as a knowledge-based destination, where ICTs, Internet of Things, and Cloud Computing and End-User Internet Service System (Buhalis &

Amarangana, 2013) are used to provide instruments, platforms (Toppela, 2010) and systems (Morelli et al., 2013) to make knowledge and information accessible to all the stakeholders in a systematic and efficient way and to make available mechanisms that allow them to participate as much as possible in the innovation process (Racherla, Hu & Hyun, 2008). In line with this perspective it has been recently argued that social media can "facilitate the transformation of the stakeholders' tacit knowledge into an explicit codified knowledge, which can be stored, shared, and consequently combined with relevant knowledge to ultimately enable better decision making" (Sigala & Marinidis, 2012, p. 106). In addition, Funilkul and Chutimaskul (2009) argued that Web has become the medium through which users and stakeholders interact and collaborate, exchange and share information and knowledge, and share opinion in an attempt to converge toward a common vision (Funilkul and Chutimaskul, 2009).
Given the still scarce research existing which analyzes how the process of knowledge sharing can be assessed, this paper aims at contributing to fill this gap by applying and mixing epidemic diffusions models and other approaches to network analysis in the case of three Italian tourism destinations.

3 Materials and methods

The ecosystems examined in this study are those of the Italian destinations of Elba, Gallura, and Livigno. These are three well-known destinations. Elba is an island off the coast of Tuscany (central Italy), Gallura-Costa Smeralda is the north-western region of Sardinia and Livigno is a mountain district in northern Italy, close to the Swiss border. The destinations are quite typical. Elba and Gallura are marine areas, while Livigno is an Alpine zone. Each destination, for the purpose of this study, is considered bounded by the respective administrative borders. The size of the three destination, in terms of tourism firms operating, is similar, about one thousand companies, as similar is their tourism intensity. They receive about half a million visitors per year, with a strong seasonality. The ecosystem networks considered have been broadly described elsewhere (Baggio & Del Chiappa, 2014a). For all the systems we consider the whole network and the two subnetworks formed by the real firms and the one made of their virtual representations (websites).

The main characteristics are reported in Table 1.

Table 1. Main characteristics of the destination networks

Destination	Type	Nodes	Edges	Density
Elba	Ecosystem	1156	2712	0.0041
	Real	713	1636	0.0064
	Virtual	443	494	0.0050
Gallura	Ecosystem	3712	9718	0.0014
	Real	2235	6077	0.0024
	Virtual	1477	2165	0.0020
Livigno	Ecosystem	751	2740	0.0097
	Real	468	1388	0.0127
	Virtual	283	566	0.0142

For all destinations the networks of core tourism stakeholders (accommodation, travel agencies, restaurants, associations, consortia etc.) were assembled from lists provided by the local tourism boards together with those formed by their websites. In these networks the links between the different actors were uncovered following the methods extensively described in Baggio, Scott and Cooper (2010). In short, connections due to commercial agreements, co-ownership, partnerships, membership in associations or consortia were uncovered by consulting publicly available sources (listings, management board compositions, catalogues of travel agencies, marketing leaflets and brochures, official corporate records, etc.). All data have been validated also via in-depth interviews to knowledgeable informants (directors of tourism boards, directors of associations, tourism consultants).

It is straightforward to think that there is a qualitative difference in the links between real and virtual elements of the network and that, when information diffusion is concerned, this translates into a difference in transmission speed. To render this difference a weighted version of the networks was prepared in which we assign value 1 to a link between two real nodes, 2 to a link between a real and a virtual node and 3 to a link between two virtual nodes, in some way translating (even if arbitrarily) the different effort levels in building and maintaining these connections.

Two works by Baggio and Del Chiappa (2014a; 2014b) have clearly shown the strong structural coupling of the real and virtual components in the digital tourism ecosystems. This coupling, as noted in the literature (e.g. Castellano, Fortunato, & Loreto, 2009), has important effects on many dynamic processes and alters the behavior of the ecosystem with respect to that of its components in ways that cannot be simply derived from the composition of the two sub-networks. This is somehow expected when dealing with a complex system, and affect two issues, the structural integration of the real and virtual components, and the diffusion and synchronization of opinions. The methods used belong to the class of spectral methods. The rest of this section discusses briefly the methodological bases for this analysis.

3.1 Knowledge diffusion and opinion synchronization

Spreading a piece of information is a process that has been studied in innumerable ways. For what concerns our cases we can use an epidemiological modelling approach (Danon et al., 2011; López-Pintado, 2008). Such models consider the individuals in a group (population) as susceptible (S) to an infection. They could then be infected (I) and finally recover (R) from infection when acquiring some form of immunity or simply become susceptible again. The infection can represent the transfer and the acceptance of an idea or a message. For what concerns information, knowledge, or opinions suitable models are those that consider S and I individuals. A first one (simple) is termed SI model. It theorizes that susceptible individuals, when exposed to a piece of information accept it and become infected. They remain in this state until the end of the process. A second one, more elaborated, is the SIS model. Here individuals, once accepted what transmitted, have a probability to *forget*, which can mimic the case in which information become uninteresting or obsolete, or some other event induce a change in a previously accepted opinion. This model has a well-known threshold τ_C which depends on the (average) capacity of individuals to *infect* others. The infection process dies when the infectivity $\tau < \tau_C$. All these processes are obviously also depending on the number and the distribution of the relationships existing in the population.

Another proposal for understanding the spreading of opinions is to treat consensus as a peculiar form of synchronization, a phenomenon which has been very well studied in different contexts by means of simple and effective models. The most popular is the one of Kuramoto (1984). Here the elements of a system are thought of as collection of oscillators coupled to each other. Each oscillator has an intrinsic frequency and a characteristic phase that might be seen as representing the individual's opinion. Linkages between individuals are given a value which constitutes a coupling between the oscillators. Here too it is shown that when the coupling K is greater than a critical coupling K_C, which depends on the system configuration and characteristics, the whole system synchronizes and all elements oscillate with the same phase, that is: a general consensus is reached and opinions are aligned (Arenas, Díaz-Guilera, Kurths, Moreno, & Zhou, 2008; Pluchino, Latora, & Rapisarda, 2005).

3.2 Elementary spectral graph theory

Spectral graph theory is a branch of algebraic graph theory that studies graph properties such as connectivity, centrality, and clustering by using the methods of matrix analysis. Moreover, spectral graph theory has proved quite effective for the investigation of network dynamic processes such as epidemic diffusion or synchronization (Van Mieghem, 2010).

Let us consider an undirected network. Usually it is represented by a geometric abstract object called graph made of points (nodes, vertices) and lines connecting them (links, edges). More formally a graph is a pair $G = (V,E)$, where V is the set of vertices and E is the set of links: ordered couples (V_a, V_b) of vertices. Such a graph can also be identified by a symmetric $n \times n$ matrix A_G, called adjacency matrix, whose elements are defined as:

$$A_G(i,j) = \begin{cases} w & \text{if } \{i,j\} \in E \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where w is the weight associated to the link. For an unweighted network $w = 1$.

For a square symmetric matrix, given a non-null vector x, if it is possible to find a scalar λ such that $Ax = \lambda x$; λ is called *eigenvalue* for A and x is the corresponding *eigenvector* (Lang, 1970). The eigenvalue satisfies the equation: $(A - \lambda I)x = 0$ which has nontrivial solutions if and only if: $det(A - \lambda I) = 0$. The latter is known as the characteristic equation of A (and the left member characteristic polynomial). There exist exactly n roots (not necessarily distinct) for this polynomial therefore an $n \times n$ matrix has n eigenvalues and n associated eigenvectors (each one having n elements). If the matrix is real (i.e. all its elements are real numbers) and symmetric (undirected network), its n eigenvalues $\lambda_1, \lambda_2, ..., \lambda_n$ are the real roots of the characteristic polynomial. The ordered set of the eigenvalues for A is called the *spectrum* of A: $sp(A) = \lambda_1, \lambda_2, ..., \lambda_n$ *with* $\lambda_1 \geq \lambda_2 \geq, ..., \geq \lambda_n$. The largest eigenvalue λ_n (also principal or dominant) is termed spectral radius.

Eigenvalues and eigenvectors of a graph are closely related to its structural characteristics; they *summarize* its topology (Restrepo, Ott, & Hunt, 2006). More precisely, eigenvalues contain global information about the network, while eigenvectors contain local (nodal) information. This is the case, for example, of a number of nodal metrics such as eigenvector centrality (Bonacich, 1987), Katz centrality index (Katz, 1953) or PageRank (Brin & Page, 1998), all calculated from the principal (largest) eigenvector of the adjacency matrix. The spectral analysis of the adjacency matrix of a network can be a useful, and in many cases computationally more efficient, method to derive its main parameters. Among the many interesting outcomes of the wide body of studies in spectral graph theory we use here one important result.

The spectral radius, the largest (principal) eigenvalue of the adjacency matrix λ_N. plays a crucial role in controlling the dynamical processes described above: diffusion and synchronization. In fact, it is found that the critical threshold for a SIS epidemic diffusion τ for an undirected graph is $\tau = 1/\lambda_N$ (Chakrabarti, Wang, Wang, Leskovec, & Faloutsos, 2008). For what concerns synchronization a similar result holds for the critical coupling that turns out to be: $K_C \propto 1/\lambda_N$ (Restrepo, Ott, & Hunt, 2005).

No matter how we model the spreading of opinion and the establishment of a consensus, the largest eigenvalue of the adjacency matrix shows the properties of these processes on a complex network: the higher its value the lower their critical thresholds, or: the higher its value, the easier is to inform and *convince* the actors in a complex social network.

4 Results and discussion

The inverse spectral radius ($1/\lambda_N$) calculated for all the networks examined is shown in Table 2. This value, as said, gives a reliable indication of the *goodness* and the *efficiency* of the diffusion process.

Table 2 The inverse spectral radius for all the networks examined

Destination	Weighted Ecosystem	Ecosystem	Real	Virtual
Elba	0.0292	0.0430	0.0434	0.0899
Gallura	0.0167	0.0433	0.0437	0.0503
Livigno	0.0194	0.0354	0.0428	0.0776

The values for the whole ecosystems are lower than those of their components and the minimum is attained by the (more realistic) model given by the weighted networks. This reconfirms the idea, already put forward, that the combination of real and virtual elements in a single well integrated system provides a more efficient substrate for the spreading of ideas or the reaching of a common agreement on some issue.

The virtual component of a tourism destination, as remarked above (Buhalis & Amaranggana, 2014) is a crucial element for an efficient functioning of a smart destination. If we accept this idea, then, it is important to verify the contribution of this component and check whether its strengthening can improve the efficiency of the whole ecosystem. Our findings, combined with those discussed in previous research (Baggio & Del Chiappa, 2014a; 2014b), strongly underline the crucial and central role the technological manifestations of tourism firms within a tourism destination play in shaping the characteristics of the tourism system.

Given the complexity of the systems, it is impossible to simply *add-up* some new contributions, therefore we need to proceed with a simulation in which the connectivity of the virtual component is augmented.

Three simulation runs were performed, in each we add (randomly) a certain proportion of links between the virtual elements and between the virtual and the real ones. In the simulations we consider both the simple (unweighted) and the weighted ecosystems and we add respectively 5%, 15% and 30% of the links existing. Due to the stochastic nature of the simulations all the results reported here are averages over ten realizations. Table 3 reports the results.

Table 3 The inverse spectral radius for the simulations performed

Simulation	Destination	Weighted Ecosystem	Ecosystem
Baseline (Table 2)	Elba	0.0292	0.0430
	Gallura	0.0167	0.0433
	Livigno	0.0194	0.0354
Base +5% links	Elba	0.0291	0.0429
	Gallura	0.0167	0.0432
	Livigno	0.0193	0.0352
Base +15% links	Elba	0.0288	0.0427
	Gallura	0.0167	0.0430
	Livigno	0.0192	0.0347
Base +30% links	Elba	0.0285	0.0424
	Gallura	0.0166	0.0424
	Livigno	0.0189	0.0338

These results clearly show the impact of the virtual component on the whole ecosystem. As a reference, for a 30% increase in connectivity the average improvement is of 2% for the weighted network and 3% for the unweighted case. This may mean an increase in the efficiency of the diffusion process of up to 40% (number of infected nodes or speed of diffusion), depending on the actual topology of the network (see e.g. Chakrabarti et al., 2008). Also, the results suggest that a more extensive and intense employment of virtual objects can have beneficial effects from a structural point of view, besides the other considerations on the favorable effects digital technologies have on the functioning and the competitiveness of a tourism destination (Law, Buhalis & Cobanoglu, 2014; Standing, Tang-Taye, & Boyer, 2014).

5 Conclusions

The scientific debate on smart cities and smart tourism destinations has been growing in the last decade. Nevertheless, the work of conceptualizing and defining what a smart tourism destination is, and how it works, can be considered still in progress. This is particularly evident when the process of information and knowledge transfer is considered. This paper aims at contributing to deepen the scientific debate around this topic.

In particular, this study shows and confirms that a strong structural cohesion between the real and the virtual components of a destination do exist, thus suggesting that knowledge-based destination management studies should consider both components of the system. The fact that the real and the virtual aspects need to be considered together when analyzing a business ecosystem is not new. However, only recently the concept of digital business ecosystem has been formally examined in a tourism context, and more specifically in tourism destination. In this paper a digital business ecosystem is considered as being an intrinsic part of the more recent concept of smart tourism destination. In such complex systems the diffusion of information and knowledge is undoubtedly an important basis for innovation and consensus development. This study, with the aid of well-established graph theoretical methods has shown how a *smart ecosystem* is more efficient in this regard.

Besides the theoretical interest, these results are important for anyone interested in the life and the development of a tourism destination. Specifically, our study suggests that the setting of a good strategy needs effective communication channels that can be exploited when the basic mechanisms for achieving the desired level of knowledge and agreement are well understood. In other words, destination marketers should focus their efforts in running internal marketing operation aimed at reinforcing simultaneously both the real and the virtual components of the ecosystem they are attempting to govern, manage, and promote. Any circumstances in which one of the two components is neglected or under-evaluated will bring to a sub-optimal level of information and knowledge sharing.

In addition to the theoretical and managerial contribution of the investigation presented here, as happens with all research, there are some limitations. First, it could be argued that this study somehow neglected the problem related to the different size and scale to which a tourism destination can be considered. According to previous research it is possible to consider regional, national and continental destinations, and analyze corporate and community tourism destinations (Flagestad and Hope 2001). That said, further research is needed to assess how the proposed methodology can be applied in such contexts. Second, in this study we argue that the higher the value of the eigenvalue of the adjacency matrix the easier is to inform and convince the actors in a complex social network. This means that our study considered only the structural side of the issue, disregarding any intrinsic actor capability or attitude. This approach is typical of all structural and dynamic network studies. It should be noted, however, that many other mediating elements may work in order to link those actors and may condition their ability to exchange knowledge or to form an opinion. These can be rendered by complicating the parameter space of the analysis and the simulations, but definitely need a deep empirical qualitative understanding of the specific situation to be assessed. Further research should investigate more thoroughly the nature of such elements and their influence on the process of information sharing and consensus development, and find practical ways to express these factors in a way that leaves the possibility to use the powerful methods used here. Finally, as discussed in previous works (see e.g. Baggio & Cooper, 2010) more effort is needed to improve the understanding of how numerical simulations can be employed for obtaining the most efficient configurations that ensure an optimal *persuasion* dynamics. Indeed, mixing epidemic diffusions models and other network analytic methods could help us in characterizing the dynamic processes and in identifying the most central and influencing nodes in the network, that can be considered the main communication target for starting the injection of information into the network so that an effective, efficient and fast information and knowledge sharing can occur.

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