Complex tourism systems: a visibility graph approach

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Abstract

Purpose

The social responsibility of a tourism destination results from the combined efforts of the single stakeholders. This needs coordination and harmonization that cannot be achieved without a deep understanding of the structural and dynamic characteristics of the destination.. A tourism destination is a complex dynamic system and requires specific methods to be analyzed and understood in order to better tailor governance actions for steering it along an evolutionary growth path, respectful of the social responsibility towards the community. Many methodological recommendations exist that allow to assess these features, and some have been successfully applied to tourism destinations. This paper explores a new proposal: the visibility graph algorithm (VGA), which is able to provide the required level of information in a fast and simple way.

Methodology

VGA is a technique to map a time series into a network. The method and its implementation are relatively simple and straightforward. The mapping allows examining the system's properties by using network analytic methods. An example is worked out using data from two destinations: Italy as a country and the island of Elba, one of its most popular areas.

Findings

The complexity properties of the two destinations are examined and found in agreement with those obtained by using more complicated approaches thus strengthening the reliability of the method.

Originality and value

This paper provides a new method to examine a tourism destination using a readily available set of data and a simple algorithm. The contribution of this work is mainly methodological. The technique provides insights into the complex structure and dynamics of a tourism destination. This has important implications for those interested in enriching the toolsets used to study a destination from a complex system perspective.

Keywords:

Tourism destinations, social responsibility, complex systems, network analysis, time series analysis, visibility graph

Article Classification:

Research paper

1. Introduction

A tourism destination is a complex and complicated ensemble of diverse components of interrelated economic, social and environmental factors, all deeply interconnected. It has been recognized to be a changing dynamic system, in which sparking events, internal or external, natural or human, can challenge existing configurations, normal operations or even the very existence of the system and can dislodge it from an equilibrium state towards different and erratic evolutionary paths. All this with a very little predictability, which makes problematic the governance of the system and the design of strategies for improving the overall effectiveness and efficiency of both the whole and its components (Farrell and Twining-Ward, 2004, Faulkner and Russell, 2001).

As a research topic, tourism is well suited for interdisciplinary research (Przeclawski, 1993). Approaches and methods originating from an assorted range of disciplines, such as economics, geography, sociology, management, have been used to understand the nature and behavior of the tourism phenomenon which is characterized by poorly defined boundaries and comprises a multiplicity of organizations offering heterogeneous products and services (Mazanec and Strasser, 2007).

Tourism products may be considered to be collections of components (such as accommodation, transport, attractions, hospitality etc.), where the relationships between the various elements are difficult to define and analyze in aggregate form, due to the variability in which different customers arrange them throughout their trip. Tourism systems can be studied by employing many different models, ideas and methods (Cooper et al., 2005), but many have raised problems about the capability of fully describing the complex and dynamic socio-economic environments of tourism. In particular, they maintain there has been little success in providing satisfactory insights into the possible development paths of such systems (Farrell and Twining-Ward, 2004, McKercher, 1999).

One useful approach to the study of the tourism phenomena is to focus on tourism destinations. These are the geographic locations where tourists spend most of their time when travelling. A destination contains “a critical mass of development that satisfies traveler objectives” (Gunn, 1997: p.27), and thus offers a tourist the opportunity of taking advantage of a variety of attractions and services. Many scholars consider it a fundamental unit of analysis for understanding of the whole tourism phenomenon, even if difficult to define precisely and problematic as a concept (Framke, 2002).

A destination has the properties of a system: an organized assembly of elements or parts (components) connected to each other with some defined relationship, and having the general objective of accomplishing a set of specific functions, or achieving particular goals (Ashby, 1956, Carlsen, 1999). The holistic systemic approach provides a broad framework that allows different perspectives to be used flexibly in the study of tourism, rather than assuming rigid predetermined views. It enables an understanding of the broad issues affecting tourism, and takes into consideration the relationships between its different components (Page and Connell, 2006).

Tourism destinations, however, are not isolated elements. They are embedded into a social and economic environment which has seen, in the last years, a number of extreme events that have profoundly changed its nature, and called for a transformation in governance styles and policy settings (Taleb, 2007, Cohen, 2012). Issues such as globalization, the relationship with the natural environment, or the need, often strongly pushed by citizens and visitors, to adopt a responsible attitude towards ensuring an ethical behavior with respect to various shareholder, employee, consumer, supplier, or competitor groups, make quite demanding the task of formulating actions or policies able to satisfy in a balanced way different needs or desires (Williams et al., 2007).

In an era of globalized and highly dynamic relationships, companies in any economic sector, and in tourism in particular, are starting to recognize the importance of acknowledging the different issues concerning their employees and their partners in the social and business environments in which they are embedded, and of a collaborative attitude in working towards a solution of broader societal problems (Knez-Riedl et al., 2006). Producing and realizing innovative ideas and actions aimed at a higher quality of life, or generating revenues, creating jobs, and investing in future development of themselves and of their social and business environments is also recognized to be more and more appreciated by consumers and result, in the end, in increased competitiveness, attractiveness and economic wealth (Vilanova et al., 2009, Mihalič, 2000).

Developing good social responsible behaviors, however, cannot be restricted to the goodwill of single firms, but needs to be addressed at a higher level. A systemic approach is definitely needed, and in this the governance of the community plays a fundamental role (Espinosa and Porter, 2011, Cordoba and Campbell, 2008). In fact, in absence of a mixture of top-down policies and individuals' virtuous behaviors, the risk, particularly high in tourism destinations, is to fall into what Hardin (1968) defined as *tragedy of the commons*. This is the depletion of a shared resource by individuals, acting independently according to their individual self-interest, even despite their understanding that depleting the common resource is contrary to the community long-term interests. As Ostrom (1990, 2010) showed, the only possible remedy is in some kind of polycentric governance, where rules and institutions resulting from governance actions coexist with a self-organized (bottom-up) management of common resources.

It seems rather obvious, thus, that efficient and effective governance, respectful of the necessary social responsibility, needs to start from an assessment of the general characteristics of the governed system, and in particular from the need to recognize to what extent the *complexity* of the system might leave room for steering it towards the desired evolutionary path.

As Helbing and Kirman note (2013: p.36): "we have created a strongly coupled and strongly interdependent world, which poses new challenges. While it is probably unrealistic and undesirable to dismantle the level of networking and globalization we have reached, there is a great potential to develop new management approaches for our complex world […] it must be emphasized that our current financial and economic problems cannot be properly addressed by remaining within the current mainstream economic paradigm. We need to change our perspective on the financial and economic system and pursue innovative policies."

In tourism, as said, the identification of destinations as systems is a useful analytical approach, but stimulates further questions on what type of system they are, what are the components and how their interactions affect their overall dynamic behavior. In a pioneering work, Faulkner and Valerio (1995), considering the deficiencies and the unreliability of many prediction and forecasting methods in tourism, called for the use of alternative ways to explain tourism dynamics, and proposed the adoption of a chaos and complexity framework. Since then, a growing strand of literature has recognized the complexity characteristics of tourism systems noting the non-linearity of the relationships that connect the different companies and organizations, and the heterogeneous responses of the various stakeholders to inputs that may come from the external environment or from what happens inside the destination (Baggio, 2008, Haugland et al., 2011). Obviously, not all systems share exactly the same characteristics and behaviors, and diagnosing the extent to which a destination may be considered a stable, a complex or even a chaotic system can be of great interest not only from a theoretical point of view, but also because it may provide crucial insights into the possibility of governing the destination (Baggio and Sainaghi, 2011, Baggio et al., 2010a).

This diagnosis can be done by employing different methods with different degrees of sophistication and intricacy. One recent proposal, however, seems to be relatively simple and straightforward and, even with some limitations, able to provide at least a first answer to the problem of assessing the 'complexity' of a system (Lacasa et al., 2008). It relies on an observable series of data taken as representative of the dynamic behavior and uses a mapping of this series into a network. In this way the powerful methods of network science can be used for the investigation.

Aim of this paper is to present this type of analysis and to provide methodological guidance. The results allow us to uncover the main characteristics of the system and to highlight a new way to understand the dynamics of tourism development. The rest of this paper is organized as follows. Next section briefly sketches the different possibilities for approaching the analysis of a tourism destination from a complex system science perspective and discusses the applicability to the theme of infusing a socially responsible attitude. The method proposed is then explained in detail. The subsequent section presents the investigation of two examples, one at a country level (Italy), and one at a local level (Elba Island, Italy). The final section contains closing considerations and addresses limitations and possible future works.

2. The study of tourism destinations as complex systems

Many complexity science methods exist. They are well known in physics, mathematics sociology and economics, but not widely used in the tourism literature where their application, although not extensive, has however provided already a good array of insights into the structure and the dynamics of a tourism destination. The general complexity characteristics of a tourism system have been explored by using non-linear time series analysis techniques, agent based numerical simulations and by applying complex network science methods (Baggio et al., 2010b, Baggio and Sainaghi, 2011, Scott et al., 2008, Cole, 2009, Johnson and Sieber, 2010).

The network science approach has uncovered important outcomes concerning destinations' structures, the functioning of collaborative and cooperative groups, the diffusion of information or knowledge across the system or the relationships between the physical and the virtual components of a destination. Additionally, the network approach has been extended to design simulation models with which different scenarios can be obtained in order to explore the possible effects of different managerial or governance actions. This provides all those interested in the life of a tourism destination with powerful tools to inform their policy or management strategies. The network perspective can offer a number of useful outcomes for tourism studies, but has also shown some limitations mainly due to the difficulty of collecting the data needed to perform a full analysis (Scott et al., 2011).

Other techniques, successfully used in many different disciplines use non-linear analysis methods applied to observational time series (Kantz and Schreiber, 1997). Popular methods employed in a variety of applications include: Lyapunov exponents, fractal dimensions, symbolic discretization, and measures of complexity such as entropies or quantities derived from them. All these techniques have in common that they measure certain dynamically invariant properties of the system under study based on temporally spaced representations of the development path. However, their application requires employing sophisticated techniques that rely, in many cases, on a good and deep experience and knowledge of the researchers. Moreover, all these methods require, for their best working, large amounts of data that are not very common in the tourism field. Even if some of these techniques have been successfully applied to the study of a tourism destination, with the help of the reasonably 'usable' software tools available, their usage and the interpretation of the results rests a task which can be difficult for many, especially practitioners (Baggio and Sainaghi, 2011). Recently, however, new methods have been proposed that allow obtaining the desired outcomes by using a time series of observations and transforming it into a network.

The idea is that it is possible to consider a time series just as a set of numeric values and play a simple game of transforming it into a different mathematical object. Then we can check what properties of the original set are conserved, what are transformed, or what can be inferred about one of the representations by examining the other. It turns out that a number of interesting insights can be derived by using this method and that this mathematical game has various unexpected practical applications opening the possibility of analyzing a time series (i.e. the outcome of a dynamical process) from an alternative perspective. Finally, since the derived representation belongs to a mature and rigorous field - network science - the information encoded in such a representation can be effectively processed and interpreted (Nuñez et al., 2012, Strozzi et al., 2009).

In this line of research different techniques have been proposed, based on concepts such as correlations, phase-space reconstructions, recurrence analysis, transition probabilities (an extensive list can be found in Donner et al., 2010 and references therein). All these have shown that different features of a time series are mapped onto networks with distinct topological properties, thus suggesting the possibility to distinguish the properties of time series, and ultimately of the system, from which they originate, using network measures (Campanharo et al., 2011, Donner et al., 2010, Yang and Yang, 2008).

Probably the simplest method, conceptually and computationally, is the one proposed by Lacasa and collaborators (Lacasa et al., 2008, Nuñez et al., 2012): the visibility algorithm. By using this technique it has been shown that a time series structure is inherited in the associated graph, such that periodic, random, and fractal series map into networks with different topologies (random, exponential, or scale-free).

A visibility graph algorithm thus allows applying methods of complex network analysis for characterizing the system in a straightforward way. In the transformation, some information regarding the time series is inevitably lost due to the fact that the network structure is completely determined in the (binary) adjacency matrix, while two different series with the same periodic succession of values would have the same visibility graph, although being quantitatively different. However, the simplicity of the algorithm and its fast implementation make it a good candidate for an initial scrutiny. Moreover a visibility graph remains invariant under several transformations of the time series data such as translation, vertical rescaling, or addition of a linear trend.

So far, a number of studies have been published in fields of stock market indices, exchange rates, macroeconomic indices, human behaviors, neurology, occurrence of hurricanes, or dissipation rates in turbulent systems (Nuñez et al., 2012).

With this method, as shown in the next sections, an assessment of the global dynamic and structural characteristics of a tourism destination becomes easier and faster than what attainable with other more sophisticated methods.

2.1 Complexity, destinations and social responsibility

A practical method for assessing dynamic (possibly complex) characteristics of a destination is an important point for all those interested and involved in the governance of a destination. In fact, it is today well recognized that driving towards a sustainable and balanced evolution is a matter that: "extends beyond the doors of the company into the local community and involves a wide range of stakeholders in addition to employees and shareholders" (European Commission, 2001: p. 11). Moreover, the main objective, as stated in the more recent European Commission document (2011: 6) is that of putting in place a "process to integrate social, environmental, ethical, human rights and consumer concerns into business operations and core strategy in close collaboration with their stakeholders". In other words, all the efforts of the single stakeholders in recognizing their social responsibility and integrating their actions should be harmonized and combined in order to obtain significant outcomes.

The main objective of any destination management organization should thus be the adoption of good governance practices for facilitating this harmonization. The issue is well acknowledged by many international institutions, and is one of the main topic in the recent ISO 26000 standard which provides guidance in the implementation of social responsibility practices. In it, the governance issue, together with community involvement and development, are central themes and much focus is posed on the identification and engagement of the stakeholders for the understanding of the different aspects of social responsibility. The ISO standard pushes for a holistic approach and identifies a number of principles (core subjects). In this respect we might state that principles such as organization, management and governance, environment, consumer issues or community involvement and development are directly related to the approach taken in this work and are directly influenced by the dynamics of the system (a tourism destination in our case) considered, and are therefore particularly addressed by the methods present in this work (see Figure 1).

Figure 1 The ISO2600 core subjects. A star marks those for which the present work is particularly significant (adapted from ISO 26000 document).

In fact, it is difficult, if not impossible, to think that the enforcement of the policy or regulatory measures needed could be obtained without taking into account the possible responses of the system to these actions. These responses are, as known, closely connected to the structural and dynamic characteristics of the system. Therefore, as well recognized by many scholars (see for example Baggio et al., 20102 or Pearce, 2013), an important initial step is the recognition these system's attributes.

3. Materials and methods

The algorithm used for mapping the time series into a network is called visibility graph. It can be described as follows. Let us consider a time series $Y(t) = [y_1, y_2 \dots y_n]$ of length N. Each data point y_n in the series can be regarded as a vertex in the associated network and an edge can be drawn connecting two vertices if the two corresponding data points can 'see' each other in the vertical bar chart of the time series. In other words: two data points are connected when there is a straight 'visibility line' that joins the points without crossing any other intermediate data bar (see Figure 2 for an example).

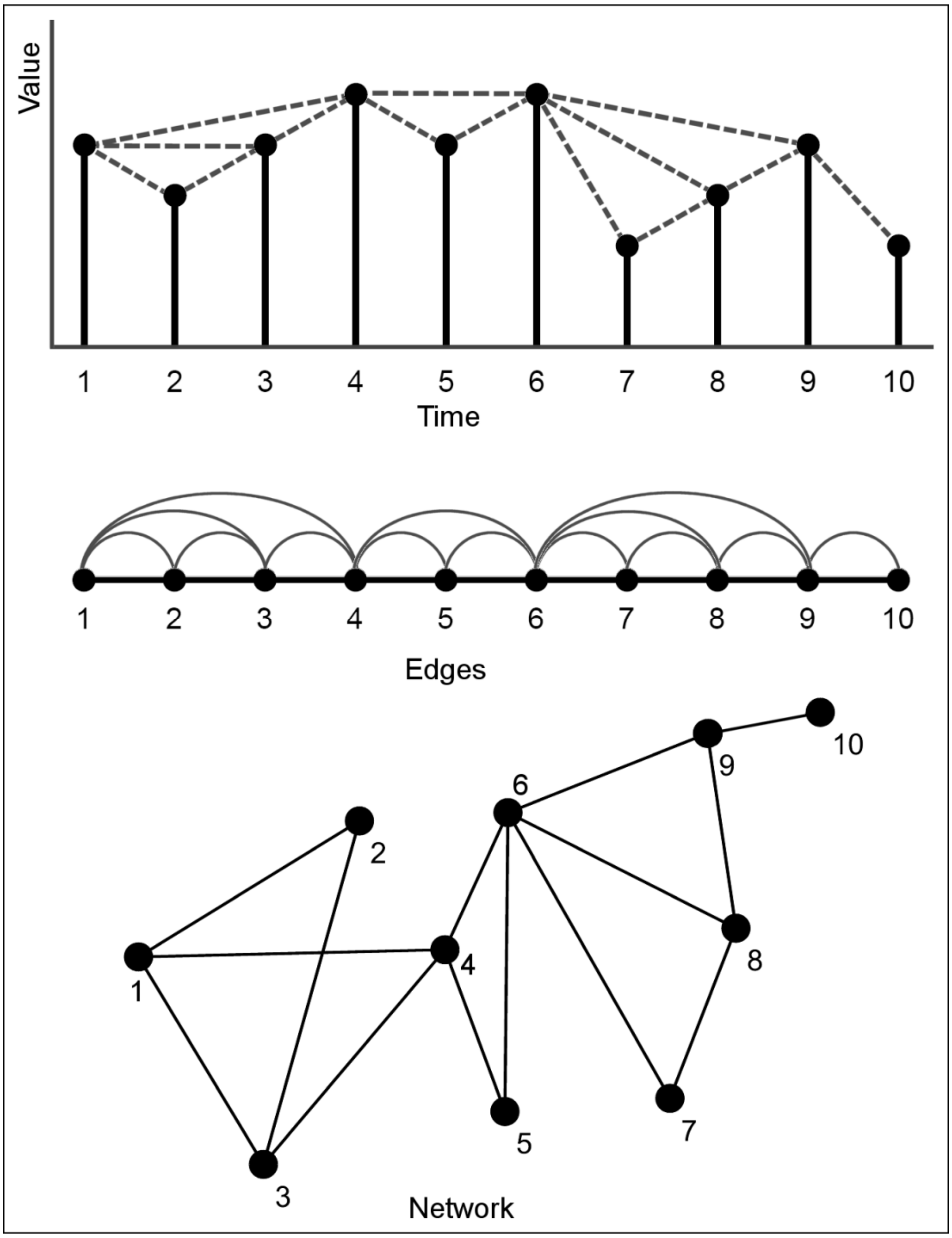

Figure 2 An example of visibility graph derived from a time series. The figure shows the original time series, the edges calculated according to the visibility condition, and the resulting network

Formally, two data values y_a (at time t_a) and y_b (at time t_b) are connected if, for any other value (y_c, t_c) existing between the two (i.e.: $t_a < t_c < t_b$), the following condition is satisfied:

$$y_c < y_a + (y_b - y_a)\frac{t_c - t_a}{t_b - t_a}.$$

The visibility graph algorithm is simple to program and runs relatively fast even for large datasets. The resulting network is then analyzed using standard techniques that consist of calculating the relevant metrics. Many of these quantities have been proposed in the last years and the literature contains a wealth of possible ways for assessing many of the structural and dynamic characteristics of the network both at a global and local level (for an extensive list see da Fontoura Costa et al., 2007, Newman, 2010). In the following section the most relevant will be employed and discussed.

The destinations used as examples are Italy and the Italian island of Elba. Using a country and one of its most representative parts also allows highlighting possible similarities or differences between a system and one of its subsystems. From a 'tourism' perspective both are interesting subjects. Italy is one of the most important tourism destinations in the World. According to the rankings published by the UN World Tourism Organization (UNWTO, 2011) Italy is at the third place in Europe and fifth in the World. In 2011 roughly 104 million tourists have spent some 390 million nights in the Italian accommodation establishments. About 46% of them are international visitors. Tourism is a quite important contributor to the country's economy and accounts for about 8.5% of the GDP and 9.5% of the employment (total contribution).

The Elba Island is a typical summer destination whose economic activities are prevalently bound to tourism. It accounts (in 2011) for about 500 thousand arrivals and 2.8 million overnight stays, 32% of the tourists are international visitors.

The series used in the analysis are the monthly overnight stays series. For Italy the series spans the period 1987-2011, for Elba 1954-2011. All data come from the official Italian statistical bureau ISTAT (www.istat.it) and from the statistical office of the Livorno province where Elba is located (www.provincia.livorno.it). The difference in length between the two series (300 and 696 points) also lets showing the flexibility of the method and its relative insensibility to the amount of data used. As customarily done the two series have been filtered to remove trend and seasonal patterns. The next section provides a guided tour for the analysis of the destination considered.

4. Results and discussion

The two networks obtained are shown in Figure 3. By construction they contain a single component (i.e. no disconnected nodes exist). The similarity in their topologies is rather evident, the apparent difference is only due to the different size of the series used. As it will be more clear in the following discussion, the two systems exhibit quite similar features. This is a first, although only qualitative, confirmation of the self-similarity of the complex Italian tourism system.

In the rest of this section, loosely following what literature provides for other cases (Chao and Jin-Li, 2012; Wang et al., 2012), the main attributes of the networks and their interpretations are discussed.

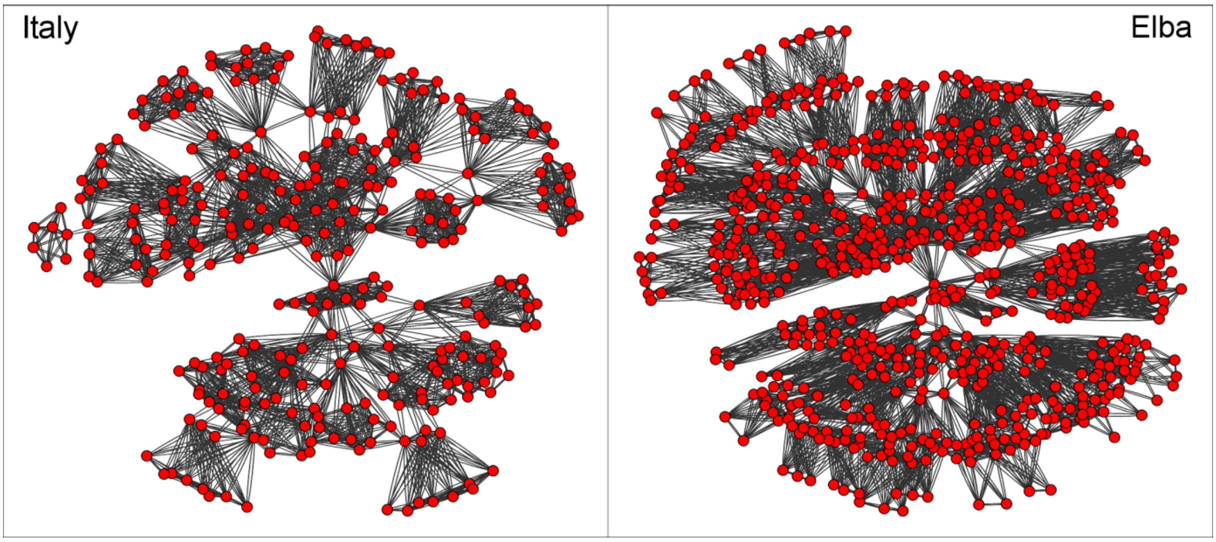

Figure 3 The networks for Italy and Elba obtained by running the visibility graph algorithm

4.1 Degrees distributions

The degree k of a node is the number of connections the node has in the network and measures how large is its direct influence on others. The statistical distribution of the degrees is an important parameter for a network and characterizes its nature. Many complex systems exhibit a peculiar degree distribution which follows a power law $N(k) \sim k^{-\gamma}$. That is to say that a few nodes (hubs) have a large number of connections while the vast majority has a limited number of links. In our case, a time value corresponding to a node with very large degree manifests a sharp and sudden rise or peak in tourism activities. The two (cumulative) degree distributions are shown in Figure 3a. The largest portion of the curves are compatible with a power law distribution, The exponents are: γ(Italy) = 2.59±0.67 and γ(Elba) = 2.54±0.73 (calculations were performed following Clauset et al., 2009). Here, again, we note the striking similarity of the two topologies.

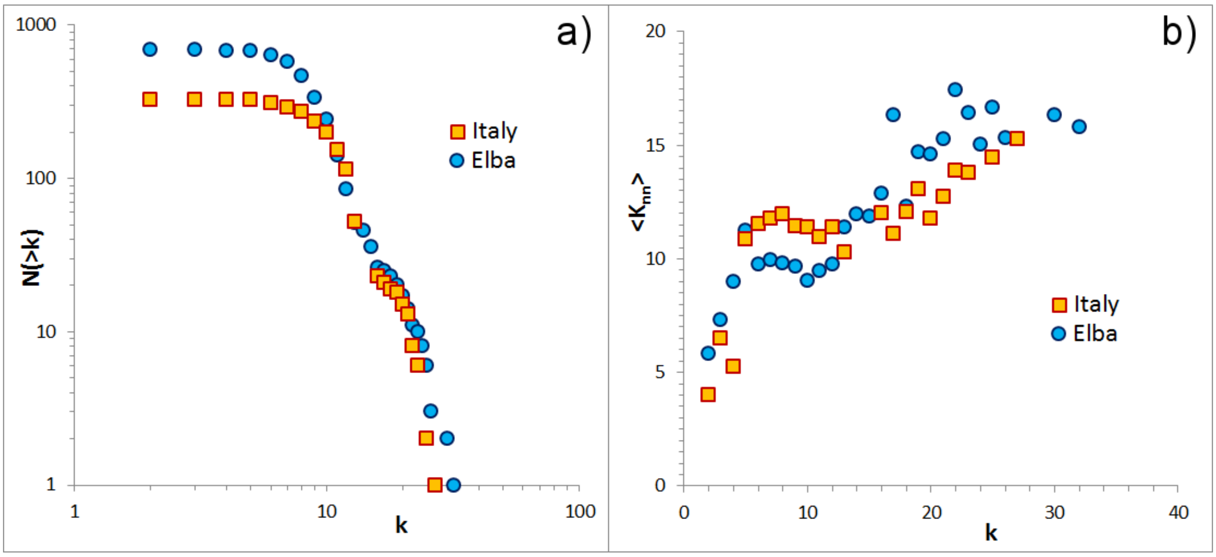

Figure 4 Cumulative degree distributions (panel a) and nearest neighbors average connectivity distributions (panel b) for both networks

4.2 Average neighbor connectivity and assortativity

The form of the degree distribution N(k) has a direct influence on the properties of a network and accounts for its basic topology. However, it cannot convey all the information on the network structure. In fact, two networks can have similar distributions yet exhibit different static or dynamic characteristics that are, generally, determined by the presence of correlations between the degrees (Gallos et al., 2008). Two quantities can provide this information: the distribution of the average degree of nearest neighbors $\langle K_{nn} \rangle$ and the Pearson correlation coefficient (r) between the nodal degrees.

The relationship plays an important role in determining the unfolding of a propagation process (perturbations, information or influence diffusion) on the network. It is reasonable to assume that if a perturbation starts from a node (and highly connected nodes are powerful amplifiers) it can affect with a certain probability its first, second, and sometimes even more distant neighbors in the corresponding network. Moreover, the resilience of a network, that is its capacity to withstand external or internal shocks without being disrupted but recovering in a reasonable period of time, is very sensitive to degree correlations (Newman, 2002).

The Pearson correlation coefficient r accounts for the attraction or repulsion tendency between similar nodes. The metric is called assortativity in network science and, in the case of a social network, can be seen as a possible expression of the attraction existing between individuals sharing similar characteristics. As a matter of fact, many social networks show a positive assortativity, while generally a negative correlation is typical of technological or artificial networks. Concerning resilience, numerical simulations have shown that a positive assortativity imply robustness against targeting high degree nodes through redundancy, since these hubs tend to be clustered forming cohesive groups. The more assortative a network is, the higher its resilience (Serrano et al., 2007).

Figure 3b shows a clear positive relationship between $\langle K_{nn} \rangle$ and k for both the destination networks examined. This is further confirmed by the positivity of the assortative coefficient for both systems: r(Italy) = 0.138 and r(Elba) = 0.316.

4.3 Clustering coefficient

The clustering coefficient C measures the concentration of connections of a node’s neighbors. It provides a measure of the heterogeneity of local density of links and quantifies how well connected are the neighbors of a vertex. The metric can provide an indication of the extent to which the tourism organizations work together collaborating or cooperating, i.e.: forming cohesive communities inside the destination. More importantly, the clustering coefficient can be used to uncover the hierarchical organization of the networked system. Ravasz and Barabási (2003) have shown that the relationship between the average clustering coefficient and the degree of the nodes signals a hierarchical structure when it follows a power-law functional form: $C_{ave}(k) \sim k^{-\alpha}$. As Figure 4a shows, this is valid for the main part of the distributions calculated for the destinations under study, and the slope of the curves are quite similar. In particular the values for the exponents are: α(Italy) = 1.28±0.12, and α(Elba) = 1.26±0.30.

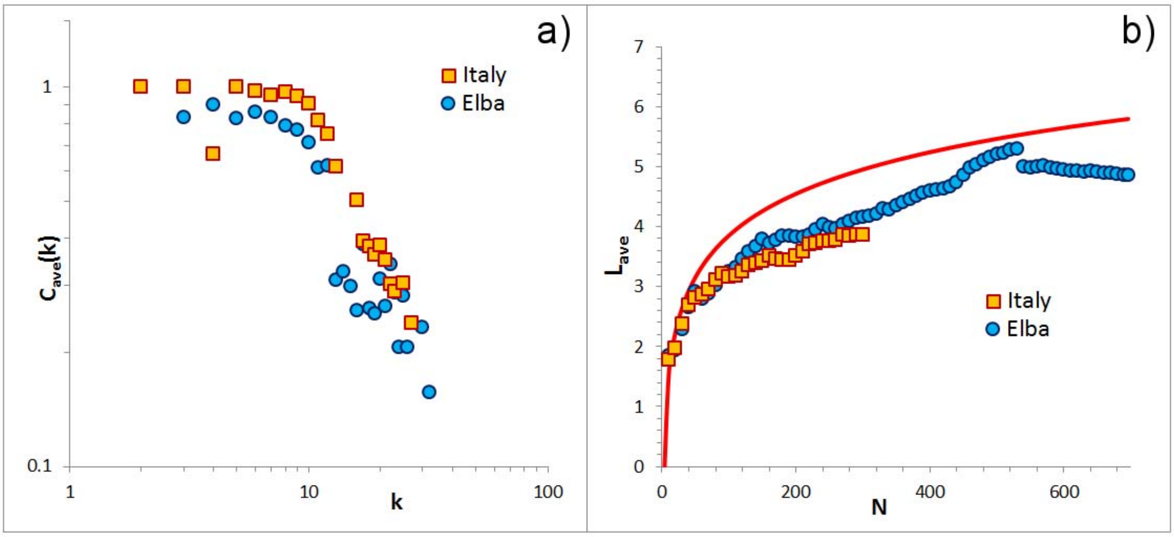

Figure 5 Average clustering coefficient as function of degree (panel a) and average path length as function of the number of nodes (panel b). In panel b the solid line represents a logarithmic relationship

4.4 Average path length and small-world behavior

The average path length is the mean value of the distance (smallest number of links) between any pair of nodes. As shown by the seminal work of Watts and Strogatz (1998), a network can exhibit a small-world behavior which is characterized by a low average path length and a high clustering coefficient, differently from what happens in a network where links are distributed randomly. Small-world is a characterizing feature of many social networks and accounts for some of the behaviors of people or groups that tend, in a social setting, to be more closely connected, mainly when displaying similarity in some of their traits.

A simple way of assessing this feature is to recall that the average path length increases logarithmically (or more slowly) with the number of nodes N: $L_{ave}(N) \sim \ln(N)$. Figure 4b shows clearly that this is the case for our destinations, therefore the visibility graphs of both networks are small-worlds.

4.5 Modularity analysis

In examining the structure of a network it is possible to find inhomogeneities in the distribution of its links at different levels. Some systems see the presence of communities (or modules). These are groups of nodes that have denser connections between them than with nodes outside the group. These assemblies are a common feature of many real systems and are important for the comprehension of their composition and evolution. Groups can be defined by some criteria such as geographical proximity, typology, or other characteristics. Besides that, groups may be formed due to the self-organization properties of the system. In this case they can be identified by using some stochastic numerical algorithms that group the nodes according to their similarity in the patterns of connections. Many methods have been proposed to uncover communities and to measure their size (Fortunato, 2010). These algorithms identify the optimal subdivision by maximizing a quality index for the partitioning called the modularity index. It is defined as:

$$Q = \sum_i (e_{ii} - a_i)^2$$

where e_{ii} is the fraction of edges in the network between any two nodes in the group i, and a_i the total fraction of links originating from it and connecting nodes belonging to different ones. In other terms, Q is the fraction of all links that lie within a community minus the expected value of the same quantity that could be found in a network having nodes with the same degrees but links placed at random. The index is always smaller than one, and can be negative when the network has no community structure, or when the number of internal links is lower than that towards other groups.

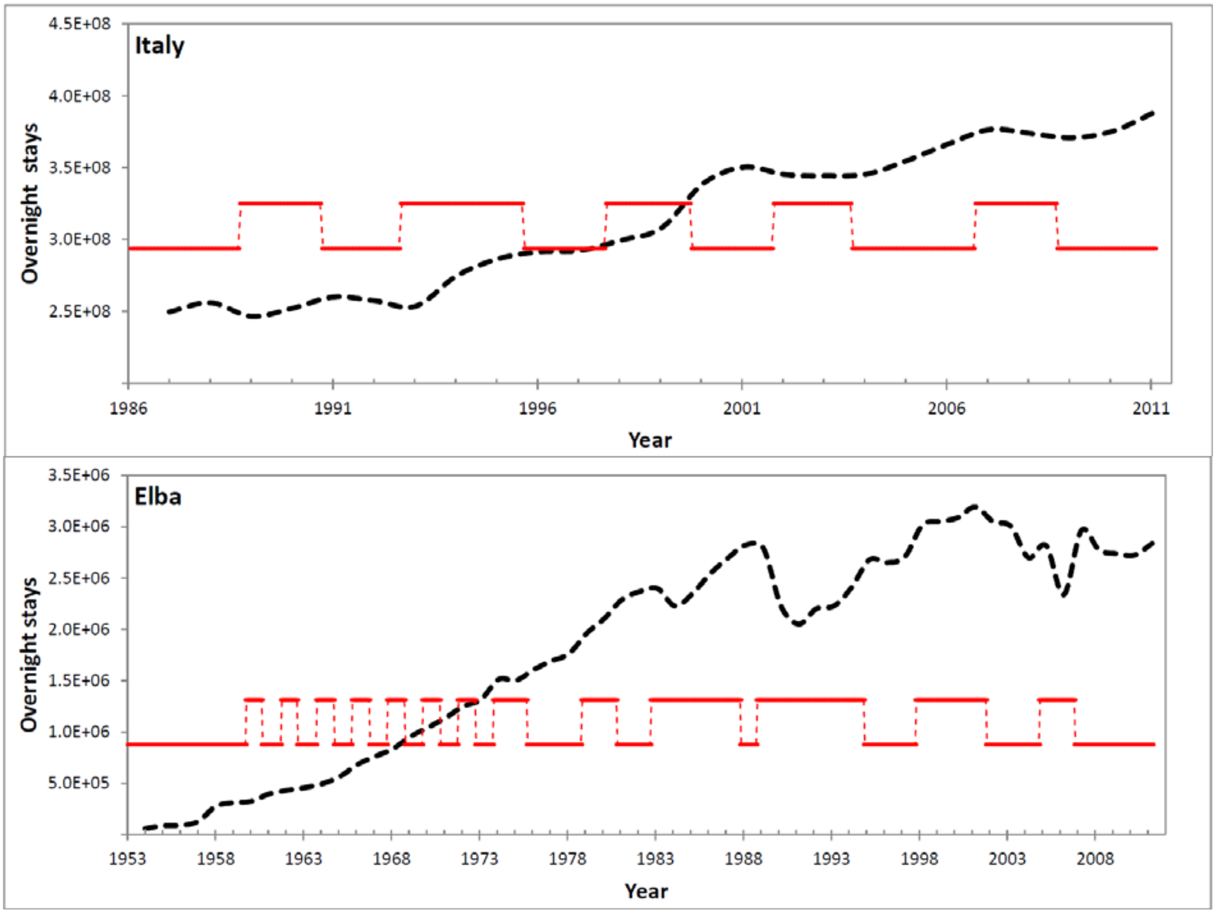

Figure 6 Annual time series and communities identified for Italy and Elba. The horizontal segments indicate the belonging of a node to a community, nodes in the same community share the same segment.

The various algorithms proposed have different capabilities to identify communities, mainly differing in their power of resolution (i.e. capability to distinguish finer structures). Here we use the one proposed by Clauset, Newman, and Moore (2004) for its speed and because we are interested in a coarse grained solution.

In the context of the algorithm used here, nodes belonging to the same community have the same dynamics in the tourism development process. Figure 5 shows the results (for the sake of readability annual time series have been used). In Figure 5 vertices belonging to the same module share the same horizontal segment. The modularity indices calculated for the solution shown are: Italy (11 communities) Q = 0.826; Elba (25 communities) Q = 0.828. These high Q values testify the goodness of the algorithm in finding well defined and separate modules.

Italy has a lower number of modules than Elba and a lower variability. This is the effect of smoothing due to the composition of many areas (local destinations) which may have different dynamics. The Elba system clearly shows an alternation between relatively stable periods and more *feverish* ones that are more evident in the big growth phase occurred in the period 1960-1975. Also, looking at the figure, long periods having the same dynamics seem to be in proximity of periods in which the growth slows down or decreases. This could indicate a reduced capability of the system to react to the external environment. This interpretation, however, will need more and deeper investigations.

4.6 A summary

In conclusion it is possible to summarize the outcomes of the study as follows. Both destinations exhibit the characteristics of a complex networked system and a good similarity in their topologies. This resemblance reinforces the idea of a tourism destination as a self-similar system (Elba is a subsystem of Italy and has a similar topology). A direct conclusion is that these are systems whose behavior is difficult to be predicted (or that the predictability window is small), and will exhibit a good resilience in case of unforeseen events (shocks).

The destinations also exhibit a hierarchical structure which testifies the existence of an emergent self-organization behavior. One immediate consequence of this fact is that policy or governance measures that do not take into account the autonomous organization of the system are destined to have little impact (see also Baggio, 2011).

The small-world characteristics of the networks show that the networks are relatively compact and clustered into small cohesive groups, similarly to many other social and economic networks. This feature has, among others, the consequence of easing diffusion processes that may occur on the network. In other words, once chosen the starting points, information or opinions could be transferred to a large proportion of the actors efficiently in relatively short times. Furthermore, in a small-world network it is easier to have a convergence of opinions with respect to networks exhibiting purely random distribution of connections (Wang and Chen, 2002). The combined effect of small-world behavior coupled with the substantial heterogeneity of the network topology has an important effect in sustaining cooperative attitudes (when they exist) among the network’s actors (Santos et al., 2005).

Finally, the modularity analysis shows that different dynamics exist in the evolution of the two systems and that high-growth periods are characterized by frequent changes in the dynamics. Long stable periods seem to lead to diminished growth or a decay of the capabilities of the system to respond to the external pressure.

The assessment of the basic characteristics of a destination has thus provided a series of outcomes that can be then used for promoting and enforcing policy measures having the objective to improve the overall *social responsibility* of the destination and of its stakeholders.

This is an important point. In fact, as well highlighted by Lebe and Vrečko (2013:3): "To establish a requisitely holistic and socially responsibly managed destination, all stakeholders within a destination should actively act environmentally and socially responsibly, and stick to high ethical standards". The hierarchical and modular structure, for example, may suggest to put in place common actions inside different groups that can then more easily integrated, and the small-world attributes make easier the process of spreading information and knowledge, thus allowing to design more effective programs. The realization of higher or lower stability in the economic dynamics of the destination allow to put in place more efficient and effective actions as they can be modulated according to the effective necessities.

5. Concluding remarks

It is increasingly recognized that responsible and sustainable behaviors, to be effective, need to be considered from a systemic point of view, and that companies are, more than ever, required to align with societal norms while generating revenues. So that corporate social responsibility could be defined as: "a business system that enables the production and distribution of wealth for the betterment of its stakeholders through the implementation and integration of ethical systems and sustainable management practices" (Smith, 2011: p. iii).

When tourism destinations are considered, the systemic approach is necessary, as well recognized by scholars (Baggio et al., 2010a, Pearce, 2013) and institutions such as the European Commission (2001, 2011) or the ISO 26000 standard (2010).

However, tourism destinations are complex adaptive systems and their complexity is a crucial characteristic which affects a number of properties of the system as well as its dynamic behavior. Therefore, a holistic and systemic approach to the implementation of policies intended to foster social responsibility practices needs to start, necessarily, from an overall assessment of the 'complexity' of such systems.

Different methods exist for performing a diagnosis, mostly based on non-linear analysis of series of values that represent in some way the outcomes of the behavioral conditions of the object of study or by collecting the appropriate data needed to build a complete network of the destination examined. Both possibilities, however, raise some issues for their inherent difficulty or for the problems met when collecting the data needed. Here a novel and relatively simple approach has been presented which uses a mapping of a time series into a network, therefore allowing network analytic techniques to be applied. In summary, we have here a simple (conceptually and computationally) and meaningful way, that uses reasonably available data for assessing the complexity features of a tourism destination system.

The results presented on the study of the two destinations are all well in line with those obtained elsewhere by employing non-linear and network analysis methods (Baggio and Sainaghi, 2011, da Fontoura Costa and Baggio, 2009, Baggio, 2009, Baggio, 2008, Baggio et al., 2010b). Other variations of the VGA algorithm have been proposed that may highlight different possible features and make the analysis more complete. These will be object of the future efforts of this line of research.

In the opinion of the author, the main limitation in the method presented here is of conceptual nature. The hypotheses made are that the main structural and dynamic characteristics of a complex system can be rendered through a series of observations (time series) and that the transformation of the time series into a network does not lose too much information thus allowing to preserve at least the key traits. Although reasonable and verified in a number of cases, these assumptions will need better and more extensive investigations before being fully accepted. For the time being, however, the conjecture seems to work well.

6. References

Ashby, W. R. (1956), *An Introduction to Cybernetics,* Chapman and Hall, London.

Baggio, R. (2008), "Symptoms of complexity in a tourism system", *Tourism Analysis,* Vol. 13 No. 1, pp. 1-20.

Baggio, R. (2009), "Network science: an interdisciplinary contribution to tourism studies", *Advances in Tourism Research Workshop held at the Competence Center in Tourism Management and Tourism Economics (TOMTE) of the Free University of Bolzano*, Brunico, Italy, September 27-29.

Baggio, R. (2011), "Collaboration and cooperation in a tourism destination: a network science approach", *Current Issues in Tourism,* Vol. 14 No. 2, pp. 183-189.

Baggio, R. and Sainaghi, R. (2011), "Complex and chaotic tourism systems: towards a quantitative approach", *International Journal of Contemporary Hospitality Management,* Vol. 23 No. 6, pp. 840-861.

Baggio, R., Scott, N. and Cooper, C. (2010a), "Improving tourism destination governance: a complexity science approach", *Tourism Review,* Vol. 65 No. 4, pp. 51-60.

Baggio, R., Scott, N. and Cooper, C. (2010b), "Network science - a review focused on tourism", *Annals of Tourism Research,* Vol. 37 No. 3, pp. 802–827.

Campanharo, A. S. L. O., Sirer, M. I., Malmgren, R. D., Ramos, F. M. and Amaral, L. A. N. (2011), "Duality between Time Series and Networks", *PLoS ONE,* Vol. 6 No. 8, p. art. e23378.

Carlsen, J. (1999), "A systems approach to island tourism destination management", *Systems Research and Behavioral Science,* Vol. 16 No. 4, pp. 321-327.

Chao, F. and Jin-Li, G. (2012), "Visitor flow pattern of Expo 2010", *Chinese Physics B,* Vol. 21 No. 7, p. art.070209.

Clauset, A., Newman, M. E. J. and Moore, C. (2004), "Finding community structure in very large networks", *Physical Review E,* Vol. 70, p. 066111.

Clauset, A., Shalizi, C. R. and Newman, M. E. J. (2009), "Power-law distributions in empirical data", *SIAM Review,* Vol. 51 No. 4, pp. 661-703.

Cohen, E. (2012), "Globalization, global crises and tourism", *Tourism Recreation Research,* Vol. 37 No. 2, pp. 103-111.

Cole, S. (2009), "A Logistic Tourism Model: Resort Cycles, Globalization, and Chaos", *Annals of Tourism Research,* Vol. 36 No. 4, pp. 689-714.

Cooper, C., Fletcher, J., Gilbert, D., Fayall, A. and Wanhill, S. (2005), *Tourism Principles and Practice,* Pearson Education, Harlow, UK.

Cordoba, J. R. and Campbell, T. (2008), "System thinking and corporate social responsibility (Guest Editorial)", *Systems Research and Behavioral Science,* Vol. 25 No. 3, pp. 359-437.

da Fontoura Costa, L. and Baggio, R. (2009), "The Web of Connections between Tourism Companies: Structure and Dynamics", *Physica A,* Vol. 388, pp. 4286-4296.

da Fontoura Costa, L., Rodrigues, A., Travieso, G. and Villas Boas, P. R. (2007), "Characterization of complex networks: A survey of measurements", *Advances in Physics,* Vol. 56 No. 1, pp. 167-242.

Donner, R. V., Small, M., Donges, J. F., Marwan, N., Zou, Y., Xiang, R. and Kurths, J. (2010), "Recurrence-based time series analysis by means of complex network methods", *International Journal of Bifurcation and Chaos,* Vol. 21 No. 4, pp. 1019-1046.

European Commission (2001), *Green paper: Promoting a European framework for Corporate Social Responsibility* (COM/2001/0366, 18/07/2001), Office for Official Publications of the European Communities, Luxembourg.

European Commission (2011), *A renewed EU strategy 2011-14 for Corporate Social Responsibility* (COM/2011/0681, 25/10/2011), Office for Official Publications of the European Communities, Luxembourg.

Espinosa, A. and Porter, T. (2011), "Sustainability, complexity and learning: insights from complex systems approaches", *Learning Organization, The,* Vol. 18 No. 1, pp. 54-72.

Farrell, B. H. and Twining-Ward, L. (2004), "Reconceptualizing Tourism", *Annals of Tourism Research,* Vol. 31 No. 2, pp. 274-295.

Faulkner, B. and Russell, R. (2001), "Turbulence, chaos and complexity in tourism systems: a research direction for the new millennium", in Faulkner, B., Moscardo, G. and Laws, E. (Eds.) *Tourism in the 21st century: lessons from experience*, Continuum, London, pp. 328-349.

Faulkner, B. and Valerio, P. (1995), "An integrative approach to tourism demand forecasting", *Tourism Management,* Vol. 16 No. 1, pp. 29-37.

Fortunato, S. (2010), "Community detection in graphs", *Physics Reports,* Vol. 486 No. 3-5, pp. 75-174.

Framke, W. (2002), "The Destination as a Concept: A Discussion of the Business-related Perspective versus the Socio-cultural Approach in Tourism Theory", *Scandinavian Journal of Hospitality and Tourism,* Vol. 2 No. 2, pp. 92-108.

Gallos, L. K., Song, C. and Makse, H. A. (2008), "Scaling of degree correlations and its influence on diffusion in scale-free networks", *Physical Review Letters,* Vol. 100 No. 24, p. art. 248701.

Gunn, C. A. (1997), *Vacationscape, Developing Tourist Areas,* Taylor& Francis, Washington, DC.

Hardin, G. (1968), "The Tragedy of the Commons", *Science,* Vol. 162 No. 3859, pp. 1243-1248.

Haugland, S. A., Ness, H., Gronseth, B.-O. and Aarstad, J. (2011), "Development of tourism destinations: An Integrated Multilevel Perspective", *Annals of Tourism Research,* Vol. 38 No. 1, pp. 268–290.

Helbing, D. and Kirman, A. (2013), "Rethinking Economics Using Complexity Theory", available at: http://www.soms.ethz.ch/paper_economics_complexity_theory (accessed May 2013).

ISO 26000 (2010), *Guidance on social responsibility*, International Organization for Standardization, Geneva, Switzerland.

Johnson, P. A. and Sieber, R. E. (2010), "An individual-based model of tourism dynamics", *Tourism Analysis,* Vol. 15 No. 5, pp. 517-530.

Kantz, H. and Schreiber, T. (1997), *Nonlinear Time Series Analysis,* Cambridge University Press, Cambridge.

Knez-Riedl, J., Mulej, M. and Dyck, R. G. (2006), "Corporate social responsibility from the viewpoint of systems thinking", *Kybernetes,* Vol. 35 No. 3/4, pp. 441-460.

Lacasa, L., Luque, B., Ballesteros, F., Luque, J. and Nuño, J. C. (2008), "From time series to complex networks: the visibility graph", *Proceedings of the National Academy of Sciences of the United States of America,* Vol. 105 No. 13, pp. 4972-4975.

Lebe, S. S., Vrečko I. (2013), "Ecolabels and Schemes: A requisitely holistic proof of tourism's social responsibility?", *System Research and Behavioral Science*, forthcoming

Mazanec, J. A. and Strasser, H. (2007), "Perceptions-based analysis of tourism products and service providers", *Journal of Travel Research,* Vol. 45 No. 4, pp. 387-401.

McKercher, B. (1999), "A Chaos Approach to Tourism", *Tourism Management,* Vol. 20, pp. 425-434.

Mihalič, T. (2000), "Environmental management of a tourist destination: A factor of tourism competitiveness", *Tourism Management,* Vol. 21 No. 1, pp. 65-78.

Newman, M. E. J. (2002), "Mixing patterns in networks", *Physical Review E,* Vol. 67, p. 026126.

Newman, M. E. J. (2010), *Networks - An introduction,* Oxford University Press, Oxford.

Nuñez, A. M., Lacasa, L., Gomez, J. P. and Luque, B. (2012), "Visibility Algorithms: A Short Review", in Zhang, Y. (Ed.) *New Frontiers in Graph Theory*, InTech, Rijeka, Croatia, pp. 119-152.

Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action,* Cambridge University Press, Cambridge.

Ostrom, E. (2010), "Beyond markets and states: polycentric governance of complex economic systems", *The American economic review,* Vol. 100 No. 3, pp. 641-672.

Page, S. J. and Connell, J. (2006), *Tourism: a modern synthesis,* Thomson, London.

Pearce, D. G. (2013), “Toward an Integrative Conceptual Framework of Destinations”, *Journal of Travel Research*, doi: 10.1177/0047287513491334.

Przeclawski, K. (1993), "Tourism as the subject of interdisciplinary research", in Butler, R. W. and Pearce, D. (Eds.) *Tourism Research: Critiques and Challenges*, Routledge, London, pp. 9-19.

Ravasz, E. and Barabási, A.-L. (2003), "Hierarchical organization in complex networks", *Physical Review E,* Vol. 67, p. 026112.

Santos, F. C., Rodrigues, J. F. and Pacheco, J. M. (2005), "Epidemic spreading and cooperation dynamics on homogeneous small-world networks", *Physical Review E,* Vol. 72 No. 5, p. art. 056128.

Scott, N., Baggio, R. and Cooper, C. (2011), "Network analysis methods for modeling tourism inter-organizational systems", in Megehee, C., Ogle, A. and Woodside, A. G. (Eds.) *Advances in Culture, Tourism, & Hospitality Research*, Emerald - JAI Press, Bingley, UK, pp. 177-222.

Scott, N., Cooper, C. and Baggio, R. (2008), "Destination Networks - Four Australian cases", *Annals of Tourism Research,* Vol. 35 No. 1, pp. 169-188.

Smith, R. E. (2011), *Defining Corporate Social Responsibility: A Systems Approach For Socially Responsible Capitalism*, University of Pennsylvania MPhil Thesis, available at: http://repository.upenn.edu/od_theses_mp/9/ (accessed Oct 2013).

Strozzi, F., Zaldívar, J. M., Poljansek, K., Bono, F. and Gutiérrez, E. (2009), "From complex networks to time series analysis and viceversa: Application to metabolic networks", Luxembourg, Office for OfficialPublications of the European Communities.

Taleb, N. N. (2007), *The Black Swan: The Impact of the Highly Improbable,* Random House, New York, NY.

UNWTO (2011), *Tourism Highlights 2011,* World Tourism Organization, Madrid.

Vilanova, M., Lozano, J. M. and Arenas, D. (2009), "Exploring the nature of the relationship between CSR and competitiveness", *Journal of Business Ethics,* Vol. 87 No. 1, pp. 57-69.

Wang, N., Li, D. and Wang, Q. (2012), "Visibility graph analysis on quarterly macroeconomic series of China based on complex network theory", *Physica A,* Vol. 391 No. 24, pp. 6543–6555.

Wang, X. F. and Chen, G. (2002), "Synchronization in small-world dynamical networks", *International Journal of Bifurcation and Chaos,* Vol. 12 No. 1, pp. 187-192.

Watts, D. J. and Strogatz, S. H. (1998), "Collective dynamics of 'small world' networks", *Nature,* Vol. 393 No. 6684, pp. 440-442.

Williams, P., Gill, A. and Ponsford, I. (2007), "Corporate Social Responsibility at Tourism Destinations: Toward a Social License to Operate", *Tourism Review International,* Vol. 11 No. 2, pp. 133-144.

Yang, Y. and Yang, H. J. (2008), "Complex network-based time series analysis", *Physica A,* Vol. 387 No. 5-6, pp. 1381-1386.