An evolving network model for the structure of visitors and services in a tourism destination

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Outline

Introduction

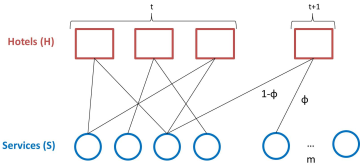
- Tourism is a geographical, economic and social phenomenon which consists on the temporary movement of some people (tourists) from origin countries to certain destinations, where they spend some time doing some activities.
- The industry is considered as a complex system and susceptible to be analyzed using complex network methodology.
- Previous contributions:
  - Limited in size ($N < 10^2$)
  - Descriptive statistics
- Our **objective** is to build an evolving bipartite network to represent the development of a tourist destination. It is based on:
  - Evolving bipartite network models [Ramasco et al. (2004), Zhang et al. (2013)]
  - Studies on within destination movements of tourists [Lew and McKercher(2006), Mckercher and Lau(2008)]

The model. Assumptions

- Assume two categories of nodes, lodgings (H) and services (S).
- A link between a lodging $i \in H$ and service $j \in S$ appears if a representative tourist of lodging i visits service j during his/her staying in the destination.
- Assume that links are unweighted, undirected and permanent.
- Assume that every lodging includes exactly c links to services ($c \geq 1$).

The model. Growing rules

- At any time $t > t_0$, one new lodging and m new services are created in the destination.
- A representative tourist of a new hotel visit c services:
  - $\phi \in [0, 1]$ of them at random.
  - $1 - \phi$ by linear preferential attachment according to service's degree $s_j(t)$.



Representation of the growing rule of the supply network of a tourist destination

- After some calculations, the evolution of s_j can be described by

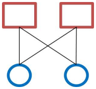
$$\frac{\partial s_j}{\partial t} = \frac{(1-\phi) m s_j + c\phi}{mt},$$

- Assuming t sufficiently large, we have

$$p(s) \simeq m(c\phi)^{\frac{1}{1-\phi}} \left(c\phi + m(1-\phi)s\right)^{-\frac{1}{1-\phi}-1}.$$

The model. Degree of the one-mode projection

- Notation:
  - $s_j \equiv$ Degree of service j.
  - $k_j \equiv$ Degree of service j in the one-mode projection.
  - $q_j \equiv$ Number of X-motifs which include service j.



X-motif

- Then, the relation between k_j and s_j is the following:

$$k_j = (c-1)s_j - q_j, \forall j \in S.$$

- We have that the probability distribution $p(q)$ first-order dominates the probability distribution $\bar{p}(q)$, with

$$\bar{p}(q) \sim \begin{cases} O(t^{-1})q^{-1-\frac{1}{2(1-\phi)}}, & \text{if } \phi > \frac{1}{2} \\ O(t^{-\frac{\phi}{1-\phi}})q^{-1-\frac{1}{2(1-\phi)}}, & \text{if } 0 < \phi < \frac{1}{2} \end{cases}$$

- So, $p(q) \simeq 0$ for t large. After some calculations,

$$p(k) \simeq m(c(c-1)\phi)^{\frac{1}{1-\phi}} (c(c-1)\phi + m(1-\phi)k)^{-\frac{1}{1-\phi}-1}.$$

The model. Degree of the one-mode projection

- Notation:
  - $h_i \equiv$ Degree of lodging i.
  - $r_i \equiv$ Degree of lodging i in the one-mode projection.
  - $s_{i_h}, h = 1...c, \equiv,$ The c services linked to lodging i.
- Then,

$$r_i = \sum_{h=i_1}^{i_c} (s_{i_h} - 1), \forall i \in H.$$

- We have that for large values of r

$$p(r) \sim c(c\phi + m(1-\phi) + m(1-\phi)r)^{-\frac{1}{1-\phi}} L(r),$$

  where $L(r)$ is a slowly varying at infinity function, similar to logarithm type (given a fix p, $L(px)/L(x) \to 1$ as $x \to \infty$).
- For low values of r, $p(r)$ is a combination of exponential functions [Ramsay(2006)].

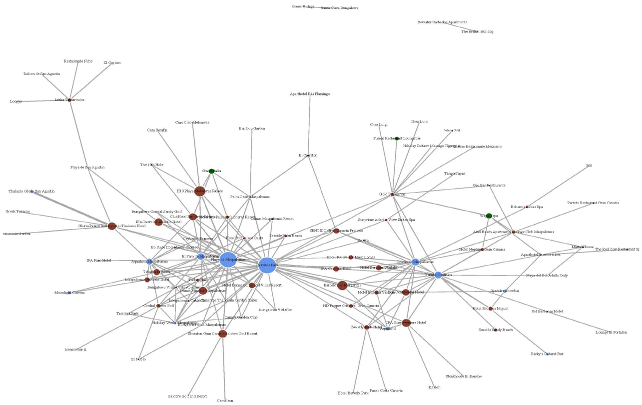
Study site and data

The data are extracted from the tourist activity developed in the southern area of the island of Gran Canaria, Spain, from 2005 to 2016.

Tourist area of Maspalomas (Gran Canaria)

The data was collected from the user opinions published in the web-site trypadvisor.com. It includes some relevant biases:

- Lodgings and services are limited to those published in the web-site.
- The sample is also limited to those registered users.

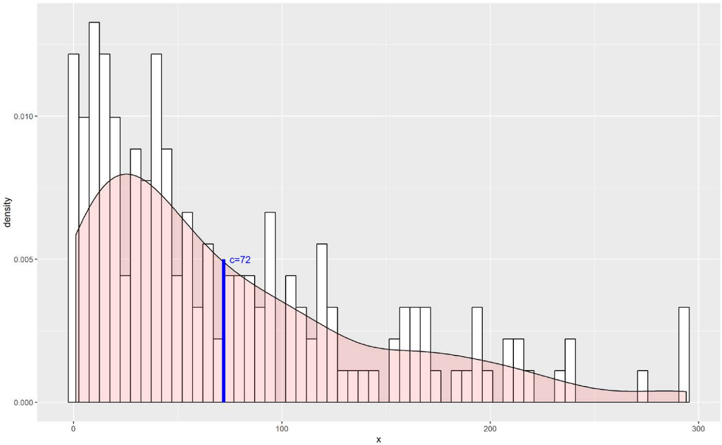


Representation of the lodging-services network. Lodgings are colored in brown, services in blue and green. The link lodging-service indicates that at least 15 opinions of the service was made by tourists hosted in the lodging. Node's degree is represented by the ball size. Edges' thickness illustrate the number of opinions.

Table 1. Basic statistics. $H \equiv$ Logings; $S \equiv$ Services; $L \equiv$ Links; $< c > \equiv$ Mean degree of lodgings; $< s > \equiv$ Mean degree of services; $\rho \equiv$ Density.

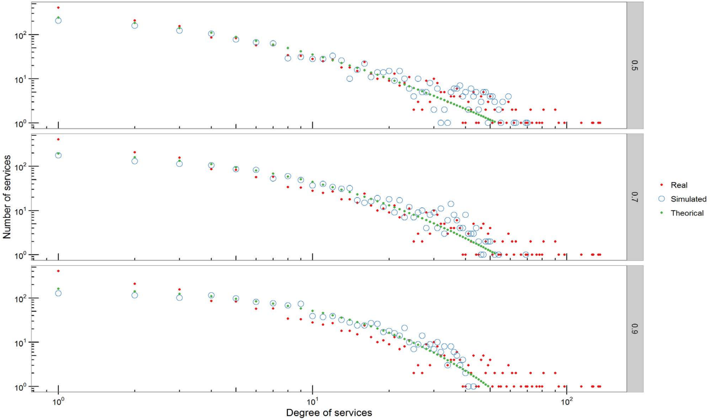
H	S	L	$< c >$	$< s >$	ρ
182	1,496	13,359	73.4	8.9	$9.5\ 10^{-3}$

Simulations and comparison with real data



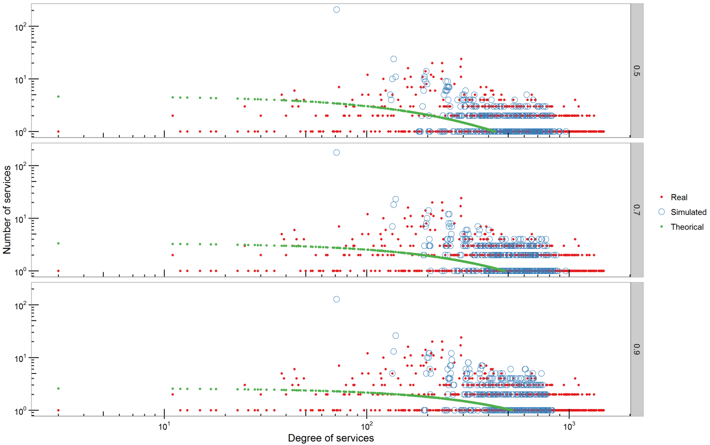
Lodgings degree distribution in the empirical sample of Maspalomas (Gran Canaria). The lodging's degree in the model is $c = 72$.

Simulations and comparison with real data



Comparison among the services degree distribution (s): Empirical (red points), simulated (blue circles) and theoretical (green points).

Simulations and comparison with real data



Comparison among the projected services degree distribution (k): Empirical (red points), simulated (blue circles) and theoretical (green points).

Conclusions

- We have built an evolving bipartite network model that represents the supply network formed by the tourist visits to services.
- The analytical results presents good agreement with simulation data.
- The model fits well real data for a specific combination of the random and preferential attachment rules.
- Extensions:
  - New comparisons with data from larger destinations in terms of visitors, lodgings and services.
  - To include distance factor in the visitors' behavior.

Thank you for your feedback!

Alan Lew and Bob McKercher.
Modeling tourist movements: A local destination analysis.
Annals of Tourism Research, 33(2):403–423, 2006.
ISSN 01607383.
doi: 10.1016/j.annals.2005.12.002.

Bob Mckercher and Gigi Lau.
Movement Patterns of Tourists within a Destination.
Tourism Geographies, 10(3):355–374, 2008.
ISSN 1461-6688.
doi: 10.1080/14616680802236352.
URL https://vpngateway.udg.edu/doi/abs/10.1080/,DanaInfo=www.tandfonline.com+14616680802236352.

Colin M Ramsay.
The Distribution of Sums of Certain I.I.D. Pareto Variates.
Communications in Statistics - Theory and Methods, 35(3):395–405, 2006.
ISSN 0361-0926.
doi: 10.1080/03610920500476325.

URL http://www.tandfonline.com/doi/abs/10.1080/03610920500476325$\delimiter"026E30F$npapers2://publication/doi/10.1080/03610920500476325.