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## Power Laws in Tourist Flows

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## **Power Laws in Tourist Flows**

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## INTRODUCTION

Power-law distribution exists in many natural, social and economic phenomena, when the frequency of an incident varies with a power of certain attribute of that incident (Mitzenmacher 2004). In the tourism field, earlier research has shown that the number of tourists visiting specific countries in a given year follows Zipf's law, a special case of the power law (Ulubasoglu and Hazari 2004). In this abstract, we show that a number of tourist flow-related variables also follow power-law distributions, including the number of tourists coming to and going out of different countries, the number of tourists who are visiting cities in the United States, and the number of outbound Japanese tourists visiting other countries. These results suggest that the power-law distribution is a common attribute of the tourism industry and it has great implications for how we view tourism as a socio-economic phenomenon.

## CONCEPTUAL BACKGROUND

Many natural and economic phenomena follow the power-law distribution. For example, in any corpus of natural language, the frequency of a word will be inversely proportional to its rank in frequency (Zipf 1949). Similar distribution has been found in magnitude of earthquakes (Abe and Suzuki 2004), sizes of cities (Gabaix 1999), internet traffics (Barabasi and Albert 1999), and sizes of companies in the United States (Li 2002). Ulubasoglu and Hazari (2004) estimated a power-law relationship for international tourist arrivals in different countries. Using the data for international tourism from the World Development Indicators database, they examined data for 89 countries between 1986 and 1990 and showed that the distribution follows a power-law distribution. Pan and Li (In Press) demonstrated that the keywords tourists use to describe the destination image of China also follow the distribution.

Power-law distributions may originate from a number of different processes. A common process that can generate the distribution is random growth (Ulubasoglu and Hazari 2004). Suppose we examine an initial set of countries, all with the same number of inbound tourists. Further, assume that all the cities have the same expected growth rate, but the actual growth rate varies. Then over time, the distribution of the number of tourists will be lognormal and/or power-law distributed, depending on a number of underlying factors. A power-law relationship will occur if there is a minimum value below which the number of visits may not drop (for example, zero), while a log-normal distribution will occur if there is not. Ulubasoglu and Hazari (2004) point out that the random growth model is consistent with a number of aspects regarding tourist visits. For example, the model stands when the number of tourists is proportional to the size of the population of the country. We test the power-law distribution and lognormal distribution of a few tourist flow-related variables and discuss the implication of the distribution on how we view tourism economy.

## METHODOLOGY

### *Data*

At a macro-level, we may argue that a country's tourist flows generally comprise three parts: inbound travel, outbound travel, and domestic travel. To investigate the applicability of power laws to

tourist flows, we examine data on variables related to tourists to and from a given set of locations. The first two variables come from the World Tourism Organization data on international tourism, and consist of the number of departures from different countries (*Worldvisits-inbound*) and the number of arrivals to different countries (*Worldvisits-outbound*) (World Tourism Organization 2010). The third variable is the number of tourists to various US cities as estimated by TNS Research International (TNS Research International 2010) (*USvisits*), while the fourth variable (*Japanvisits*) estimates the number of departures from Japan to a given country as estimated by IHG Global Insights (IHS Global Insight 2010). All the data are estimated numbers and pertain to the year of 2008, mainly due to data availability and consistency concerns.

### Statistical Method

We used linear transformation of the power function to estimate its parameters for all four models. If  $x$  is distributed as a power law, then its density function  $f(x)$  would be:

$$f(x) = Cx^{-\alpha}. \tag{1}$$

The probability that a given observation exceeds a particular value  $S$  is then given by:

$$P(S > x) \propto x^{1-\alpha}. \tag{2}$$

For simplicity, we will refer to  $\alpha-1$  as  $\zeta$ . If one were to take the observed distribution of  $x$  and order the observations from lowest to highest, then the rank of each observation would be proportionate to the probability that  $S$  exceeds  $x$ :

$$Rank \propto x^{-\zeta} \tag{3}$$

Taking the natural log of both sides of equation 3 yields:

$$\ln(Rank) \propto -\zeta \ln(x) \tag{4}$$

Gabaix (2008) recommends estimating  $\zeta$  from equation 4 by using OLS to estimate:

$$\ln(Rank_i - 1/2) = \beta_0 + \beta_1 \ln(x_i) + \varepsilon_i \tag{5}$$

Where the OLS estimate of  $\beta_1$  (which we will designate  $b_1$ ) is an unbiased estimator of  $\zeta$ . We use this approach to estimate the power law exponent for all six tourism variables. Gabaix also shows that using this approach, the standard error of the estimator of  $b_1$  is  $b_1 / \sqrt{n/2}$ .

## RESULTS AND DISCUSSION

The descriptive statistics and the results of estimating equation 5 for each of the four variables are reported in Table 1 and their graphical representation of the log-log transformation are shown in Figure 1. The results show that different tourism variables vary in the estimated slope parameters in the log-log transformation.  $b_1$  is an indicator of the concentration of the large values and its share in the whole cumulative distribution. Larger values of  $b_1$  indicate less extreme values in the distribution. Thus, visits to cities in the U.S. ( $b_1=1.972$ ) are more evenly distributed than the outbound tourists from different countries in the world ( $b_1=0.042$ ). In the latter case, the extreme values are more prominent: the top departure countries and areas like Hong Kong, Germany, United Kingdom and United States, have much larger values than very small countries such as Vanuatu and Samoa. Table 2 also shows the international visitation for different countries roughly follows the 20-80 rule. That is, the top 20% of

countries have 80% of the market share. However, the visitation to U.S. cities is more evenly distributed: the top 50% of cities have a little more than 80% of share. In the case of Japanese outbound visitors, the top 20% of destinations have nearly 90% of share, indicating a more concentrated distribution on the top countries.

In addition, lognormal testing shows that Japanese outbound tourists are significantly different from lognormal distribution while all other three distributions are not. This indicates the segmentation for a specific market follows different underlying process versus the industry-wide statistics.

## CONCLUSION

This study adds one more piece of empirical evidence to the ubiquity of the power-law distribution in both physical and social environments. By showing that many forms of tourist flows also exhibit the properties of power laws, this study could have important theoretical and empirical implications. Normal distributions have been the assumption of many tourism variables and thus statistical methods such as ANOVA and linear regressions were widely used. Although it is often difficult to distinguish between a log-normal and a power-law distribution, it is worth investigating because of the different properties exhibited by the two distributions. Of primary importance is that fact that a lognormal distribution has a well-defined mean and variance, while for a power law this fact is only true if  $\zeta > 2$ . For a power law defined as in equation (2), if  $\zeta < 1$ , then the mean and all other higher moments are undefined, while if  $1 < \zeta < 2$ , then only the mean, but no other moments are defined. These properties have profound implications for statistical testing and forecasting.

Power-law distributions can be generated by a random growth process (sometimes called proportionate growth) (Mitzenmacher, 2004), which is an example of the "winners-take-all" phenomenon (Frank, Cook, & Rosen, 1995). The proportionate growth model implies that relative standing changes only slowly, and there is little to no "reversion to the mean" over time; in other words, the original size of the city or country can create a sort of growth momentum, in which big market shares can generate even bigger market growth in the future. With top destinations being overloaded by an increasingly large amount of visitor arrivals, the sustainable usage of resources in these destinations could become more of a challenge. These seem to be at odds with the central spirit of sustainable tourism and could present a fundamental test to the tourism development model countries and cities have been following. From a forecasting perspective, the current findings seem to suggest that tourist arrivals to individual destinations may be estimated by the destination's rank (Ulubasoglu and Hazari 2004). Ulubasoglu and Hazari (2004) asserted that, if the power-law distribution holds true, then estimating tourist arrivals does not need to consider the principles of comparative advantage or price competitiveness any more. Future research needs to further explore and verify this assertion, which seems to defy the present marketing paradigm tourism competition works under (Li & Petrick, 2008).

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Table 1. Descriptive Statistics and Estimation Results

| Variable                    | # Obs. | Mean    | Max      | Min     | Std. Dev. | $b_1$ | Std. Err. | $R^2$ | LogNormal Shapiro Wilk test (p) |
|-----------------------------|--------|---------|----------|---------|-----------|-------|-----------|-------|---------------------------------|
| <i>Worldvisits-inbound</i>  | 100    | 8639160 | 78449000 | 754000  | 13469254  | 0.783 | 0.111     | 0.902 | 0.171                           |
| <i>Worldvisits-outbound</i> | 80     | 8755800 | 81911000 | 19000   | 16868257  | 0.462 | 0.073     | 0.789 | 0.781                           |
| <i>USvisits</i>             | 100    | 5451180 | 24978000 | 2634000 | 3670238   | 1.972 | 0.279     | 0.972 | 0.476                           |
| <i>Japanvisits</i>          | 101    | 277000  | 4534000  | 1000    | 725553    | 0.955 | 0.134     | 0.867 | 0.007                           |

Table 2. Overall Distributions of Four Tourist Flows

| International Arrivals 008 |                    |                     |
|----------------------------|--------------------|---------------------|
| Top N Countries            | Top % of Countries | % of Total Visitors |
| 1                          | 1%                 | 9%                  |
| 2                          | 1%                 | 15%                 |
| 5                          | 3%                 | 33%                 |
| 10                         | 6%                 | 48%                 |
| 31                         | 20%                | 78%                 |
| 77                         | 50%                | 95%                 |
| 155                        | 100%               | 100%                |

| International Departure 2008 |                    |                     |
|------------------------------|--------------------|---------------------|
| Top N Countries              | Top % of Countries | % of Total Visitors |
| 1                            | 1%                 | 12%                 |
| 2                            | 3%                 | 22%                 |
| 5                            | 6%                 | 48%                 |
| 10                           | 13%                | 67%                 |
| 16                           | 20%                | 78%                 |
| 40                           | 50%                | 96%                 |
| 80                           | 100%               | 100%                |

| U.S. City Visitation 2008 |                 |                     |
|---------------------------|-----------------|---------------------|
| Top N Cities              | Top % of Cities | % of Total Visitors |
| 1                         | 0%              | 3%                  |
| 2                         | 0%              | 4%                  |
| 5                         | 1%              | 10%                 |
| 10                        | 2%              | 15%                 |
| 106                       | 20%             | 57%                 |
| 264                       | 50%             | 83%                 |
| 529                       | 100%            | 100%                |

| Japanese Outbound Visitors 2008 |                    |                     |
|---------------------------------|--------------------|---------------------|
| Top N Countries                 | Top % of Countries | % of Total Visitors |
| 1                               | 1%                 | 16%                 |
| 2                               | 2%                 | 31%                 |
| 5                               | 5%                 | 53%                 |
| 10                              | 10%                | 72%                 |
| 20                              | 20%                | 89%                 |
| 50                              | 50%                | 99%                 |
| 101                             | 100%               | 100%                |

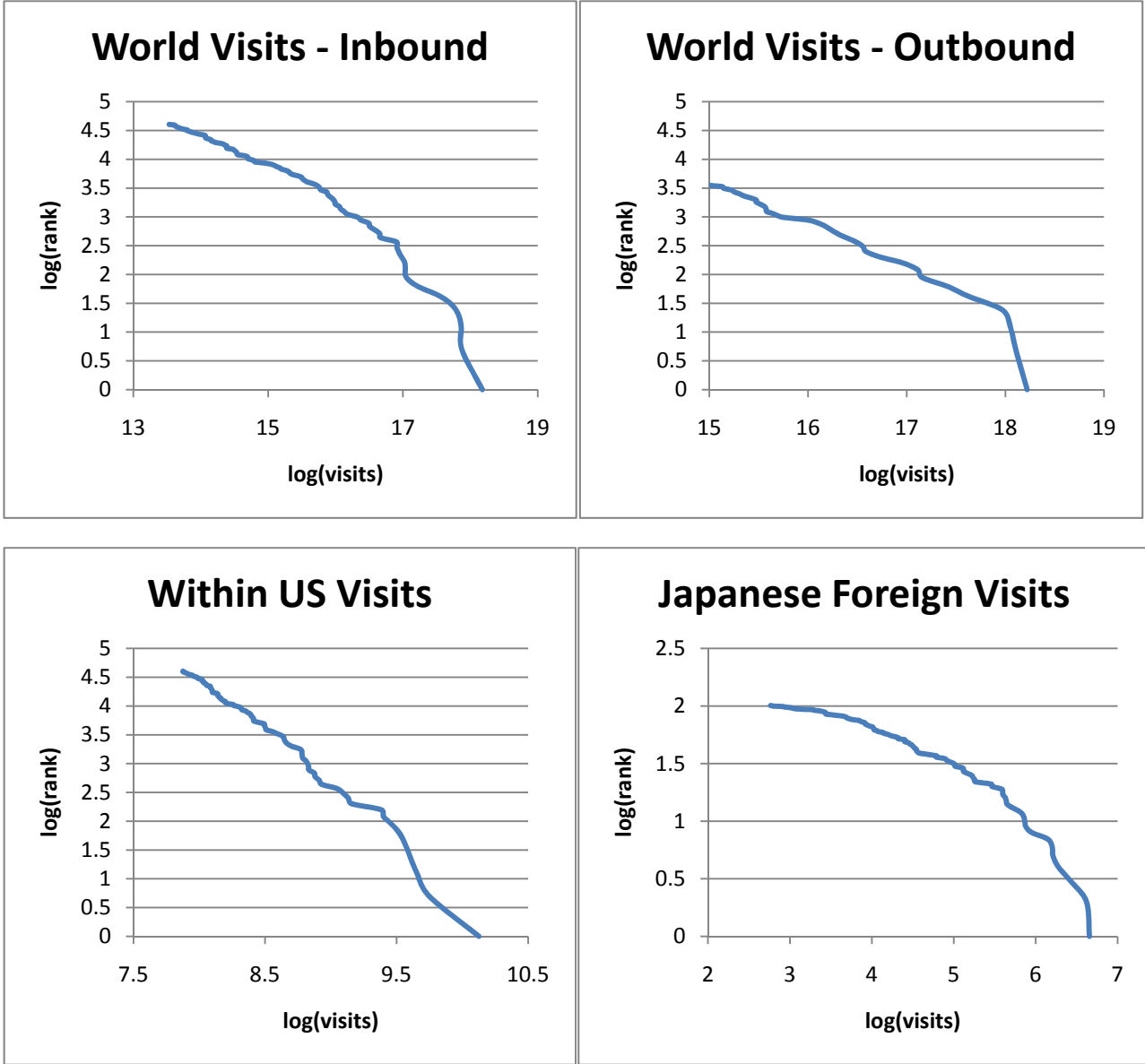


Figure 1. Log-Log Plot of Four Tourism-Related Visits