

Ranking influential communities in networks

What can citation data reveal about the flow of influence in scientific fields?

Finding communities

How to group journals into fields using random walks

The Infomap algorithm (Rosvall & Bergstrom 2008; PNAS 105) looks for a clustering of nodes that gives the shortest possible description of a random walk around the network.

Every node has a two-level address, identifying a community and the node's position within that community. It is like a street address, comprising a street name (position) and city name (group). Street names are often re-used between cities, but every street-city pair is unique.

By aggregating the journals in each community into a single 'super-journal', we can model the exchange of citations between disciplines.

Right: the Web of Science network. Each node represents a community of journals. The edges represent interdisciplinary citations.

Below: journals and citations within the statistics community.

Statistics

77 journals
29,000 citations

Acknowledgements

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Thanks to Thomson Reuters for providing Journal Citation Reports data in a convenient format.

R code and full output from the analysis is available on GitHub:
<https://github.com/Selbosh/user2017>

Given a set of paired comparisons, the Bradley-Terry model estimates an ability score for each object, such that

$$\frac{P(i \text{ beats } j)}{1 - P(i \text{ beats } j)} = \frac{\mu_i}{\mu_j}$$

for any pair of objects i and j .

Citations between academic journals can be treated as paired comparisons: being cited means being an 'exporter of intellectual influence' (Stigler 1994; *Statistical Science*).

Using ability scores, we can predict the probability that journal i cites journal j more than j cites i . Influential journals are more likely to be cited by other influential journals.

Statistical model

The Web of Science network consists of 10,713 journals, 112 communities, and 9.1 million citations. The network is highly interconnected, with many journals citing across multiple fields. The size of the nodes represents the number of journals in each community, and the thickness of the edges represents the volume of citations between communities.

The network shows a clear hierarchical structure, with some fields like biomedical sciences and engineering having many smaller communities (journals) within them. Other fields like mathematics and physics have fewer but larger communities.

The network also reveals interesting cross-disciplinary connections. For example, there are strong links between fields like psychology, sociology, and management, which are typically considered social sciences. There are also significant links between fields like engineering, mathematics, and physics, which are often seen as more technical or applied sciences.

The network provides a valuable resource for understanding the flow of influence and knowledge between different fields of science. By analyzing the structure of the network, researchers can gain insights into the dynamics of scientific communication and the evolution of scientific fields over time.

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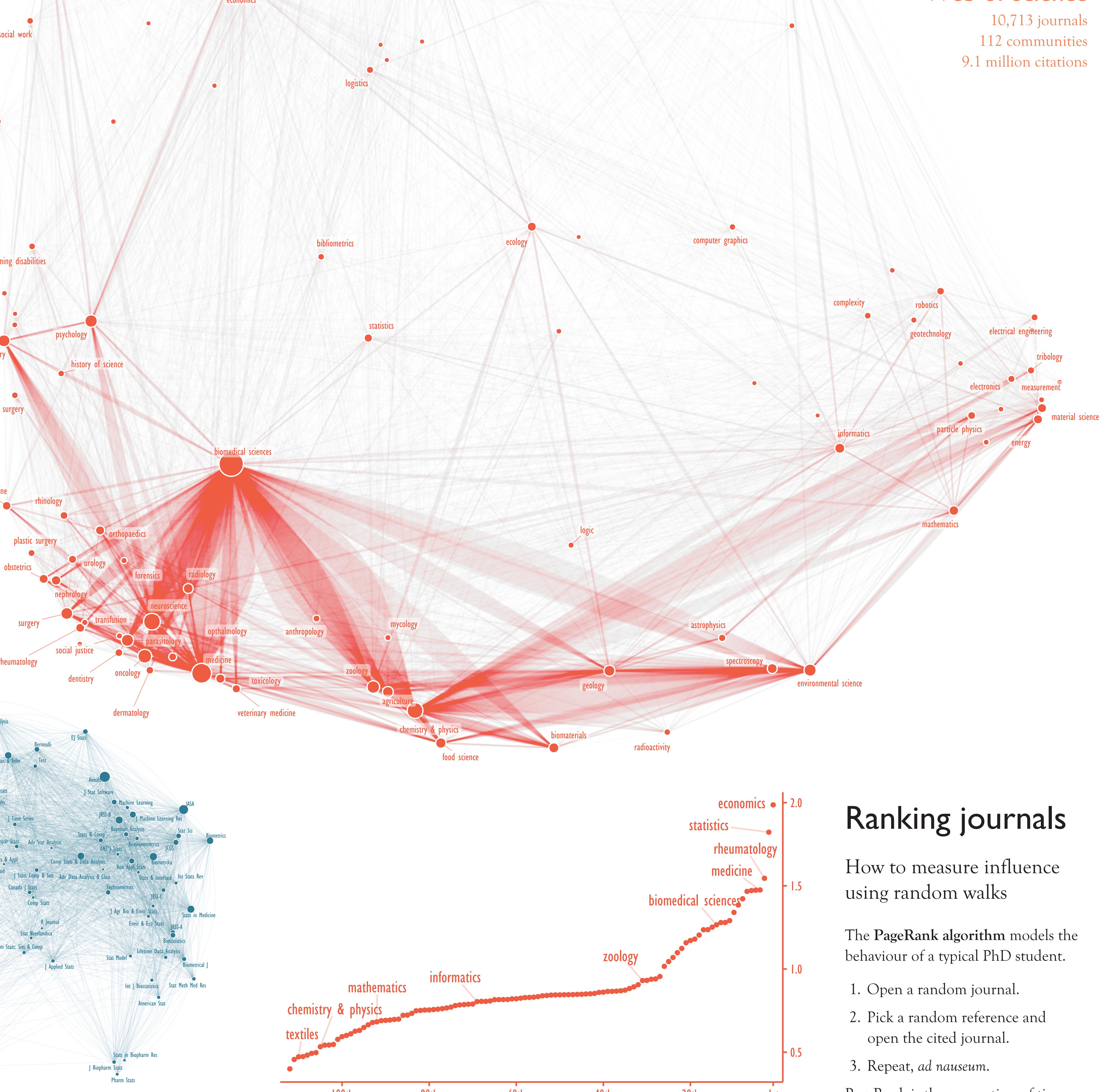
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Web of Science

10,713 journals

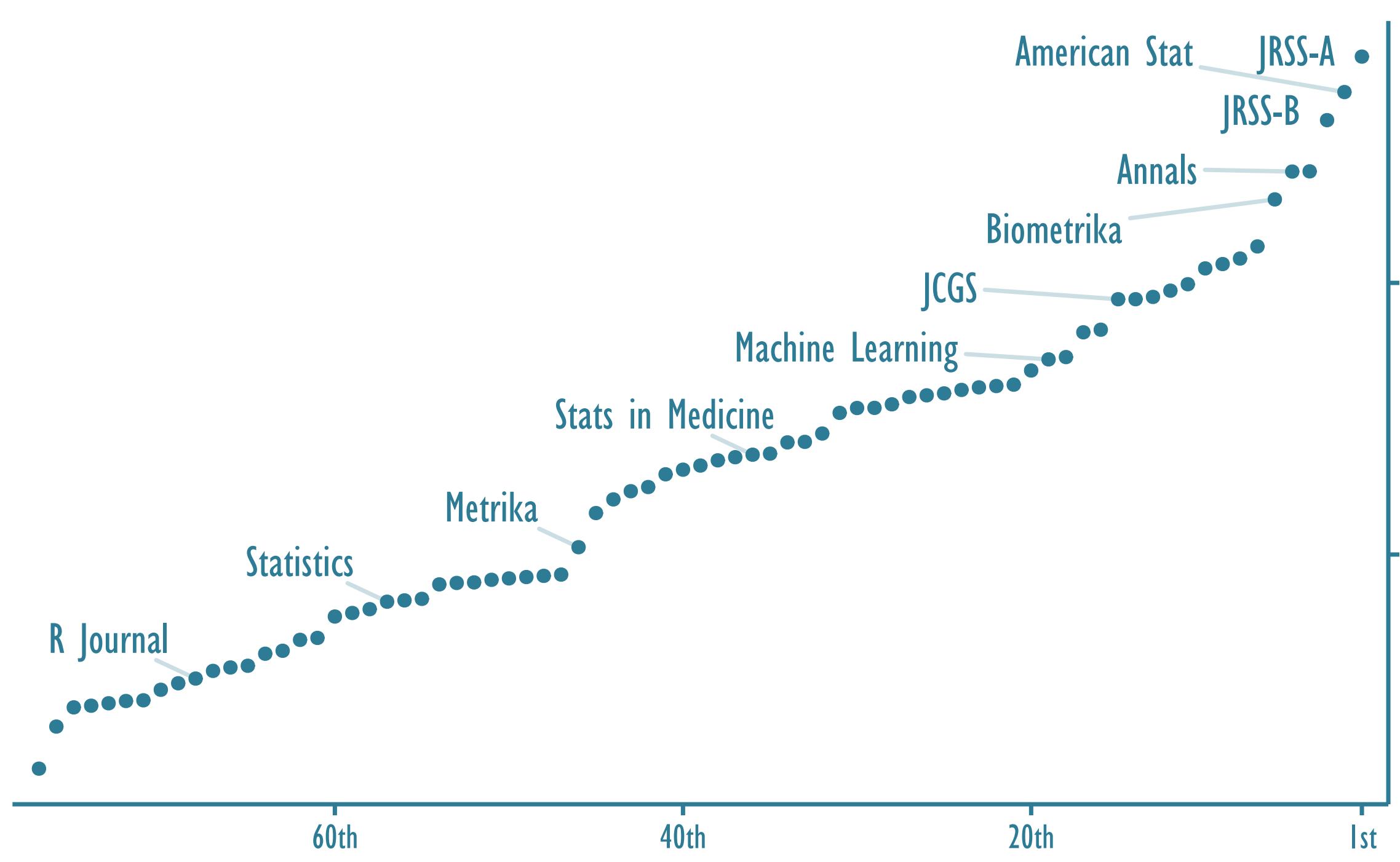
112 communities

9.1 million citations



Above: a between-fields ranking. Applied, general disciplines tend to have higher Bradley-Terry ability scores than highly specialised or theoretical ones.

Below: a within-field ranking for statistics journals. A high score implies the journal is influential within statistics, but not necessarily influential on other fields.



Ranking journals

How to measure influence using random walks

The PageRank algorithm models the behaviour of a typical PhD student.

1. Open a random journal.
2. Pick a random reference and open the cited journal.
3. Repeat, *ad nauseum*.

PageRank is the proportion of time spent reading each journal, i.e. the stationary distribution of an ergodic Markov chain. It is a measure of total influence.

PageRank has a size bias: bigger journals have more/longer articles in them, attracting more citations. What if we want to measure prestige, rather than popularity?

The Scroogefactor score, defined as PageRank *per reference*, controls for this size bias. It measures influence weight per outgoing citation.

Like the Bradley-Terry model, journals are, in effect, penalised for being generous with citations and rewarded for being miserly. When the Bradley-Terry model fits exactly, a journal's Scroogefactor is exactly equal to its Bradley-Terry score.