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Productivity and impact analysis: Rediscovering the obvious

Introduction

The ideas presented here are based on experience over the past couple of decades with the literature of astronomy and astrophysics (including cosmology and solar system studies), a field so small that it makes not even a dimple in diagrams of anything compared to biology, chemistry, medicine, or engineering. An advantage is that one can still, just barely, read the 6000 papers published each year in the four high-impact journals of the field, and about 20 others, and attribute papers and citations to specific observational facilities and to specific subdisciplines by actually looking at the papers.

The best is the enemy of the good

Significant choices are necessary before data collection ever begins. A common one is to consider only the most cited papers or the journals with the largest impact factors, which obviously results in a considerable saving of effort, but which can lead to various errors and omissions. KING (2004) seems to have identified the countries he would consider from only the 1% of 1997.2001 papers that were most cited in the ensuing years, and in so doing he has left out some countries that are equally or more productive by other measures (BRAUN, 2005).

A similarly draconian approach to the recent literature of astronomy and astrophysics would leave out (a) many astronomically productive countries (all but the US, UK, Australia, and member nations of the European Southern Observatory), (b) all but 11 of the roughly 250 optical and infrared telescopes that produced astronomical results published in 2001 (the 11 being owned by the same set of countries plus Canada), and (c) all but three of the 20 subdisciplines we work on (TRIMBLE et al., 2004), with results appearing only in the four high-impact journals.

In case you are interested, the subjects that make the cut are cosmology (the large scale structure and evolution of the universe), normal galaxies, and quasars. Stars, the solar system, our own Milky Way Galaxy, and even hot topics like gamma ray busters and planets outside the solar system disappear. Of the contributing telescopes, you are most likely (depending on your nationality) to have heard of the Hubble Space Telescope, the Keck twin 10-meter telescopes in Hawaii, the Very Large Telescope (four 8-meter mirrors owned by ESO but located in Chile), or the Anglo-Australian Telescope (only about 4 meters in diameter but used by some very hard working Australians and Brits).

Another way of saying more or less the same thing is the point made by ZUCKERMAN (1988) and by WHITE (2004) that most of the total body of citations each year goes to papers and authors somewhere in the middle of the pack, and not to either superstars or to the truly obscure.

Is there some better arbitrary cut that can be made? Perhaps not. SANCHEZ & BENN (2004) pull out the 10% of astronomy papers that were most cited in some interval and succeed in making their favorite telescopes look outstanding (but again at the price of leaving some national communities, subdisciplines, etc., essentially unrepresented).

KLAICH & KLAICH (2004) in their search for excellence in Croatian science look at the top 10% of journals (impact factor) in each of 27 disciplines. Internal evidence suggests that this is too many for some subfields and too few for others. It would be too few for astronomy, the top two of 20 (rather than top 4) introducing an enormous Anglophone distortion.

I conclude that by choosing to focus on what seems to be truly excellent science, one may not miss only most of science but most of the good science.

The wealth of nations

World-class science is expensive, experimental particle physics and overnational astronomy probably more so than any other sort, at least per practitioner. For instance, the on-going cost (not construction, instrument development, etc.) of a night of observing on one of the well-supported 4-meter telescopes is about $10,000 (GILMOZZI & MELNICK, 2004). This rises to $20,000 per night for the 8- and 10-meter mirrors at the VLT and Keck, and to about $100,000 for an equivalent amount of time on the Hubble Space Telesope (SMECKER-HANE, 2004).

Typical expenditures for telescopes, even large one (like the 6-meter in Russia) in poorer countries are smaller by an order of magnitude. And what dis the result? Precisely as you would expected. Work done with these (no matter by whom) yields not only fewer papers per square meter of collecting area but papers with much smaller impact factors (TRIMBLE et al., 2004).

KING.s (2004) plot of citation intensity vs. wealth intensity (roughly per capita incomes of the countries considered) shows a similar effect, in that the relationship is more nearly quadratic than linear. It would probably look more linear if the horizontal axis were per capita income at the purchasing power parity exchange rate rather than the official currency exchange rate, and this would make some (though not complete) economic sense. Labor to build and maintain your telescopes and process your data in India will be less expensive than in Japan. Optical-quality glass and photon-counting light detectors may not be.

My own favorite indicator is the ratio of astronomers (numbers of the International Astronomical Union) in a country to its GNP. This comes remarkably close to a constant (near 3 × 10-10 for GNP in 1996 US dollars; TRIMBLE, 2000). Japan equals India, the two parts of China look the same, and the major “overachievers” are parts of the former Soviet Union and its spheres of influence and Israel. These same overachievers also are above scale in King’s tabulations. But a given number of astronomers located in poorer countries (including the overachievers) produce many fewer papers and less-cited papers than the same number of astronomers in a prosperous country. Whether something like purchasing power parity or the square of GNP is the more appropriate correlate would be an interesting question to investigate.

The 400-pound American gorilla

Within living memory, the US had or used about half of everything expensive in the world - automobiles, electricity, telescopes, good scotch, . In recent years this has dropped to more like one-third (ECONOMIST, 2004), with the European Union accounting for another third and the rest of the world for the reminder. The gradual overtaking of the USA by the EU in publications, citations, and super-star papers, noted by KING (2004) is undoubtedly associated with this economic change. But the US still publishes about one-half of the high-prestige journal papers per year, and it is widely believed (and noted by King as .anecdotal evidence.) that American authors preferentially over-cite other American authors (or, perhaps, journals) thus unfairly biasing various averages and indicators of productivity and impact.

Yes and no, as is often true with folklore. It is possible to think of journals as individuals and count up whether the citations in a particular journal are to papers in the same and other journals in proportion to the total papers published in each. Within astronomy, all journals over-cite themselves (TRIMBLE, 1993). That is, for instance, papers published in the Russian (but fully translated) Astronomy Reports have more than a proportionate share of citations to other Astronomy Reports papers. But all journals over-cite (relative to the number of papers appearing there) the largest, highest profile American publication, Astrophysical Journal, which, therefore, ends up having the largest impact factor of the (non-letter) journals in the field. More than half the articles published there now include authors from other countries, and there is no indication that their papers are less cited than other ApJ ones. Perhaps these people count as honorary Americans.

They count in any case as actually or honorarily wealthy, because ApJ (like other American journals of astronomy, but unlike many other disciplines and other nations) imposes page charges on its authors (at a rate of $110 per printed page) which are taken quite seriously.

Conclusions

The points made here are (a) the best is the enemy of the good when you are trying to decide who does good science, where, and how, (b) it is better to be rich than poor, at least if you want to do science, and (c) American authors are not really much more parochial than others, once allowance is made for (b). None of these points is in any way unique to citation analysis, or, for that matter, very new, but keeping an eye out for them, as well as for other long-established principles (BRAUN, 2005), can perhaps make citation analysis more useful by allowing it to do more nearly what we want it to do.

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