Journal of Informetrics 12 (2018) 1063–1071

Contents lists available at ScienceDirect

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi

Regular article

Information and misinformation in bibliometric time-trend analysis

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ARTICLE INFO

Article history:
Received 9 March 2018
Received in revised form 23 August 2018
Accepted 23 August 2018

Keywords:
Time series
Citation analysis
Research policy
International comparisons
China

ABSTRACT

A diachronous time-series of bibliometric data (using all data available) suggests rising normalised citation impact (nci) for Germany and other G7 nations, while China suffers a decline in later years of any series. This is shown to be a consequence of the time-series, which has led to an erroneous interpretation of real trajectories. A synchronous series (using fixed time windows) based on the final year suggests a lower trajectory while a diachronous series tracking the fate of a single publication year reveals that nci progressively falls for Germany and the USA whereas it climbs for China. This has implications for research policy and for the interpretation of changes in the competitive research environment in the presence of dynamic growth. By analogy, this may extend to institutional as well as national comparisons. It has implications for analytical methodology, supporting prior suggestions that recent papers should be omitted from citation analysis.

1. Introduction

The utility and value of citation impact indicatorshas been recently reviewed by Waltman (2016). Like all pieces of data about research activity, publications, to which citations accrue, are characterized by three pieces of metadata: discipline (what is the topic?); time (when was it published?); and location (where was the author based?). It is widely understood that, because citations accrue over time at rates that are field-dependent, a basic pre-requisite of any analysis is that raw citation counts should be indexed against an appropriate global benchmark for discipline (Adams, Gurney, & Jackson, 2008; Moed, 2005) and time (Waltman, Van Eck, Van Leeuwen, Visser, & Van Raan, 2011).

Elsevier (2013) report on the UK's international comparative research performance is an example of a typical analysis and statement. In the report's Fig. 4.6, the UK's average field-weighted citation impact is shown as a rising trajectory and underpins the claim that the citation impact of UK articles is high and rising (and greater than that of any comparator economy). Indeed, the report asserts with precision that UK impact increased at 1.28% per year in the period 2008-12 (the 2017 report did not include such precise figures). Similar examples are widespread in the literature, though most do not go so far as to provide collateral for government claims of national performance.

A trend analysis (time series) assumes that successive data points draw on like-for-like data. A common example would be the varying number of animals at the same location over some period. Apart from the obvious challenge of a total population count, requiring some standardised sampling technique, it is also necessary to stipulate that the sampling periodicity is

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https://doi.org/10.1016/j.joi.2018.08.009
1751-1577/

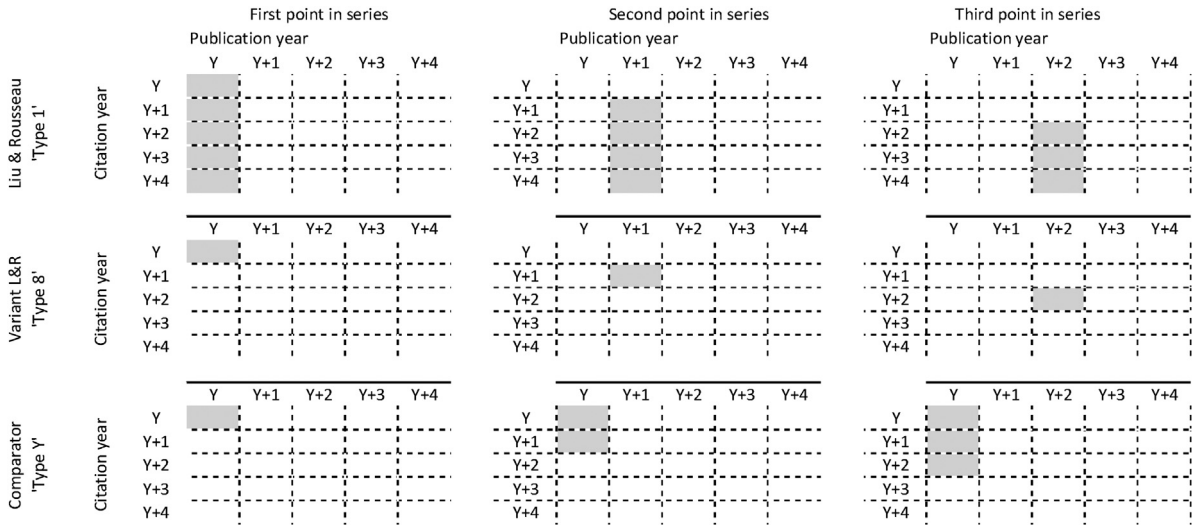

Fig. 1. The publication-citation data matrices (cf. Ingwersen et al., 2001) used in three time-series to explore outcomes in analyses of comparative international research performance. The data for the first three points in each time-series are illustrated, showing the relevant publication year and citation time window. The graphical style and model typology follow Liu and Rousseau (2008).

constant and - critically - that the environment remains the same (Adams, 1980). The simplest bibliometric trend analysis uses an annualised publication set (for country, organisation, discipline or some mix) and the count of citations to that set accumulated from publication to the present (i.e. a diachronous index *sensu* Ingwersen, Larsen, Rousseau, and Russell, (2001); a Type 1 analysis *sensu* Liu and Rousseau (2008): Fig. 1)), normalised for field and publication year against the relevant world average for that field and year. If several countries are analyzed in this way and the resultant annual, average, normalised citation impact (nci) is plotted against time then we can observe both their relative positions and lines that implicitly track secular changes, so long as the global environment remains constant.

The implication is not, in fact, correct. Following Liu and Rousseau (2008): Section 3) we note that an analysis for the USA over the decade from 2007 to 2016 starts with 2007 papers and their accumulated cites over ten years to 2016, then adds 2008 papers with cites for nine years to 2016, and so on for successive later publication years and successive shorter citation periods. This time series does not *track* the USA's performance: the assumption of like-for-like is violated because the time series is a sequential set of independent publication datasets with different citation time-periods. The environment (global pool and national data) and time frame (citation period) differs in each annual instance. The time frame (and the disciplinary composition) may be accounted for by normalisation; the rest is not. Hence, any change in relative status of the comparator data over the period from the earliest year is wholly obscured. That problem is overcome in widely-used alternative methodologies (such as those developed at Leuven and Leiden) using fixed citation windows.

This distinction may be of no consequence if the serial data sets are also a true reflection of changing national relativities, but the global environment has not remained constant. For a long period, from 1945 until the 1990s, the world research base was mostly the G8 and was rather stable: one year looked much like another. That is no longer the case, particularly with the rise of China, South Korea, and more generally across the G20.

The analysis in this paper tests the counter-proposition: that the implicit trends in some variant time-series analyses might misrepresent the true time-based evolution of contemporary relative national performance. If so, then care should be taken in choosing which of these variants is used to inform policy or evaluation. Specific instances will be given regarding the interpretation of the relative citation performance of China and some G7 economies, which suggests not only that interpretation is dependent on the analytical structure but also that location factors in citation trajectory may need further examination in policy-related studies.

The motivation for this analysis is not that one methodology is innately better, although some may conclude that. It is about the influence of methodology on interpretation: different perspectives allow different views, some of which lead to different conclusions. The motivation draws particularly on two background sources. First, Glänzel and Moed (2013) suggested that "the annual publication output of a dynamically growing or declining small research unit might distinctly deviate from the general trend of the reference standard. The ... nonlinearity and non-homogeneity of the superposing citation processes might then result in a bias." Not only is China's growth dynamic; it is also a large research unit that influences the competitive environment for all other units.

Second, Glänzel (2004) drew attention to the distinction between synchronous and diachronous calculations of citation impact (Ingwersen et al., 2001). Synchronous indices use a constant year or set of years (which may mean omitting some known data) whereas diachronous indices use all available data but may then use different sets of citing years for publication years. Frandsen and Rousseau (2005) developed the idea, illustrating this with calculations of article impact over arbitrary