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# Properties of an index of citation durability of an article



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## ABSTRACT

Citation Delay ( $D$ ) introduced by Wang et al. (2015) is a measure of citation durability of articles reflecting information on the entire citation life-time. The characteristics of the measure and relationships of it to other article characteristics are examined in the six different fields using the citation data over 15 years of the articles published in 2000 in these fields.  $D$  distributes normally with good approximation and is not so much dependent on the subject field as the citation count. Although articles with higher  $D$  (more lately cited) tend to gain more citations in their life-time, this relationship is not linear but the mean of citations reaches a maximum at a certain value of  $D$ . Multiple regression analysis explaining  $D$  showed that articles with a higher Price index (i.e. citing more recent references) will receive most of the citations relatively earlier and that there is a weak tendency that articles containing more figures are cited earlier and those containing more tables are cited later. A seemingly contradictory result is found that more highly cited articles tend to have higher citation durability in individual journals while high-impact journals tend to include more articles with lower citation durability in higher proportions.

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## 1. Introduction

The number of citations an academic paper receives is often used as a measure of the scientific impact of the paper. However, papers with the same total citation count can show different time distribution patterns of the count. Many articles are rarely cited for some time after publication, then receive a growing number of citations to arrive at a peak somewhere between two and six years after publication, before the citation count decreases, while some receive most of the citations within a year or two, others are cited constantly for a long period, and still others remain unmarked before a sudden wave of citations arrives seven or ten years afterwards.

How citation counts change over time, in other words, ageing (obsolescence) or durability of citations has been studied from various viewpoints (see Section 2 for details). However, knowledge about citation durability of articles is less accumulated compared with that about citation count itself. One of the essential reasons for it is thought to be that any quantitative index for measuring citation durability is not established yet.

The classification into early-cited (flash in the pan), delayed-cited (sleeping beauty), and normal is often used (Garfield 1980; Glänzel, Schlemmer, & Thijs, 2003; van Dalen & Henkens 2005; van Raan 2004), but the criteria of the classification differ by the authors. Some aging parameters such as the cited half-life (median of citation age distribution) do not reflect the entire pattern of life-time citations. In contrast, the Citation Delay introduced by Wang, Thijs, and Glänzel (2015) is

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the measure of citation durability reflecting the entire life-time citation information, but little has been known about its properties.

Although the systematic investigations comparing the relation of citation durability with other characteristics of articles are not so many because of a lack of the established index of citation durability, several works have reported that delayed recognized papers tend to receive more citations in the long run than early recognized ones (Aversa 1985; Costas, van Leeuwen, & van Raan, 2010; Levitt & Thelwall 2008; Levitt & Thelwall 2009; Line 1984; Wang 2013). It is, however, not clear if this conclusion applies to any subject field because the samples employed in these investigations were either limited to a small number of highly-cited papers (HCPs) or composed of papers from various fields.

The relation of citation durability with characteristics other than citedness of articles has been addressed by only a few studies. Among those, van Dalen and Henkens (2005) and Costas et al. (2010) classified papers into four classes, i.e., [I] few-cited, [II] early-cited, [III] delayed-cited and [IV] normal, and compared the characteristics of the papers within each class. Wang et al. (2015) investigated the influence of interdisciplinarity of an article and some article features on the Citation Delay mentioned above. However, van Dalen and Henkens (2005) only made comparison of each class II, III and IV with the class I, and did not explicitly show any difference among the former three. In Costas et al. (2010) and Wang et al. (2015), the relationships between citation durability and various properties of articles were reported rather briefly because their studies mainly focused on other issues (development of general methodology for the classification of research publications according to the citation durability in Costas et al., and examination of the relation between citation durability and interdisciplinarity of articles in Wang et al.).

Citation Delay introduced by Wang et al. (2015) is considered to be the most appropriate measure for citation durability among those that have ever been proposed. Using this measure as an index of citation durability of articles, the present work sets up its purpose as follows:

- (1) Elucidating the characteristics of the distribution of Citation Delay;
- (2) Examining relationships between this durability index and the citation count of articles in different subject fields to reveal whether or not there is any difference in the long-range citation counts between early-cited and delayed-cited articles; and
- (3) Examining relationships between the durability index and other characteristics of articles in different fields to reveal tendencies common to these fields.

In Section 2 I briefly review previous studies related to the present work. Section 3 explains the durability index, the data and method used in the subsequent analysis. Section 4 and Section 5 describe the results and discussion, respectively, and Section 6 gives main conclusions obtained from this research.

## 2. Literature review

### 2.1. Developing mathematical models for aging of papers

Studies on the obsolescence function that describes temporal changes of the citation count has been made for a long time. The most simplistic approach is to fit it to an exponentially decaying curve, but it is not adequate even qualitatively because the citation count is generally recognized to reach its peak a few years after publication.

Avramescu (1979) proposed two types of ageing function  $c(t)$  describing the citation count after a lapse of time  $t$ , which can fairly approximate the citation history of numerous articles by adjusting three parameters in those functions. Egghe and Ravichandra Rao (1992) examined the ageing factor  $a(t) = c(t+1)/c(t)$  and proposed a log-normal model for  $c(t)$  based on the empirical observations that in many cases  $a(t)$  has a minimum at a certain  $t$ . Burrell (2003) analyzed citation age distribution (yearly change of citations received by articles) based on the failure rate function in the reliability theory, and supported the conclusion by Egghe and Ravichandra Rao (1992).

Glänzel and Schoepflin (1995) used a stochastic model for the process to acquire citations from a set of articles (e.g., those published in a certain journal in a certain year) and defined indices for the speed of early reception and for later ageing. Based on applications of these indices to actual cases, they showed that the ageing patterns depend on discipline rather than journal, and that slow ageing does not necessarily mean slow reception.

Della Briotta Parolo et al. (2015) investigated the change of citation decay with publication year for articles published during 1960–1990 and found that the more recently the articles were published, the faster they reach the citation peak and also the shorter their citation half-life becomes. In addition, they showed that the citation trajectories after the peak year fit better to exponential decay than power law decay.

### 2.2. Comparison of citation durability between highly cited papers (HCPs) and other papers

Early studies by Line (1984) demonstrated that highly cited papers (HCPs) have longer citation durability. This findings raised interest in the citation age distribution of HCPs.

Aversa (1985) and Cano and Lind (1991) characterized the citation ageing pattern for a long period of HCPs they selected, i.e., 400 HCPs published in 1972 in case of Aversa and ten HCPs from two disciplines chosen by Garfield as “citation classics”

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