

# Bibliometric Characteristics and Citation Impact of Funded Research: A Case Study of Tribology

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## ABSTRACT

The purpose of this study is to compare the bibliometric characteristics between funded and non-funded publications in the field of tribology. The Science Citation Index – Expanded (SCI-E) is used to retrieve the bibliographic records related to the tribology research. Bibliometric indicators such as number of publications, number of citations, funded ratio, and average number of authors, author keywords, and references are employed. A new relative indicator called Relative Funding Index is introduced in this study. The results of this study show that more than 55% of tribology research publications were funded and number of funded publications has increased dramatically. Funded research publications have higher number of cited references and international collaborative papers than non-funded ones. However, the share of single authored publications is lower than non-funded ones. There is no difference in citation impact between funded and non-funded research.

**Keywords:** Scientometrics, Science Funding, Funding Ratio, Citation Impact, Tribology.

## INTRODUCTION

The funding of science, to the extent that it leads to publication, helps to promulgate relevant knowledge and publications consequently an essential aspect of publicly funded science. Publication expands the opportunities for different users of scientific results to access the knowledge and skills base in the scientific community created by public investment in research.<sup>[1]</sup> During the 20<sup>th</sup> century, science was increasingly funded by governments and corporations vying for military and economic advantage.<sup>[2]</sup> Many national funding decisions are supported by citation and publication metrics, e.g. the national Norwegian

model for research performance, the upcoming UK Research Excellence Framework and the Chinese academic evaluation system.<sup>[3]</sup> Even though the funding of science theoretically plays a substantial role in scientific discoveries, its relation to outcomes has not been extensively researched.<sup>[4]</sup>

The present study intends to investigate the bibliometric characteristics between funded and non-funded research publications. To illustrate this, bibliographic records relating to tribology research (highly interdisciplinary field) were retrieved from Science Citation Index – Expanded of WoS.

The term Tribology was introduced by Jost in a report in 1966.<sup>[5]</sup> According to American Heritage Dictionary, tribology is the science of the basic mechanisms of friction, lubrication and wear of interacting surfaces (i.e. mechanical ‘things’) that are in relative motion. It is a highly interdisciplinary research field which incorporates a number of disciplines such as physics, chemistry, metallurgy and engineering.<sup>[6]</sup> Tribological applications not only to improving car engines but also to hip joints and cosmetics, shrinking devices to micrometer and nanometer scales, and expanding the range of temperatures, speeds, and chemical environments where devices operate.<sup>[7]</sup> Tribology remains as important today as it was in

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### Access this article online

Official Publication of	Website: www.jscores.org
	DOI: 10.5530/jscores.6.1.6

ancient times in the fields of physics, chemistry, mechanics, geology, biology, and engineering.<sup>[8]</sup> It is emerging from the realm of steam engines and crank-care lubricants and becoming a key to vital new technologies such as nano-technology and MEMS.<sup>[9]</sup>

## RESEARCH QUESTIONS

The present study is designed to answer the following questions based on a sample of tribology research publications: How many publications have been funded by funding agencies? Does funded research have a higher citation impact (or number of highly cited papers) than non-funded? Does international collaborative papers of funded receive higher citation impact than non-funded research? Which types of research publications have been funded more?

## METHODOLOGY

The bibliographic records on tribology research were drawn from Science Citation Index – Expanded. The following keywords were used in the combined fields of title, abstract and keywords: \*tribology\* OR “tribosyst\*” OR “tribo-syst\*” OR “tribo-chem\*” OR “tribochem\*” OR “tribotechn\*” OR “tribo-physi\*” OR “tribophys\*”.<sup>[10-11]</sup> The search was carried out on May 2015 and restricts the literature to articles, reviews and proceeding papers published during 2008-2014. Because, the Web of Science (WoS) has been started recording the funding information from August 2008. The retrieved data was exported to MS-Excel for further analysis.

### Highly Cited Papers

Papers receive five times of average citations per paper are considered as highly cited papers.

### Un-cited Paper

A paper which has not received a single citation from its time of publication until May 2015 is called as an un-cited paper.

### Funded Publication

Research papers that acknowledge research grant funding.

### Funding Ratio

To calculate the funding ratio, the following formula given by Tan *et al*<sup>[12]</sup> is used.

$$FR = \frac{FP}{TP} \times 100\%$$

Where FP is the number of funded publications and TP is total number of publications for the calculating unit.

### Relative Funding Index

To the best of my knowledge, there is no indicator to compare the funding ratio of a unit with the average of the data set. In this context, a new relative indicator called Relative Funding Index (RFI) is introduced in this study. Relative Funding Index (RFI) is introduced in this study.

$$RFI = \frac{\text{Funding Ratio of the calculating unit}}{\text{Funding Ratio of the data}}$$

RFI = 1 indicates that the funding ratio of a unit is equal to the average; RFI > 1 (or RFI < 1) indicates that the funding ratio of a unit is greater (or lower) than the average funding ratio. This indicator characterizes the science funding behavior of the calculating unit for research activities.

## RESULTS

Table 1 provides the general bibliometric characteristics between funded and non-funded research publications in the field of tribology. More than 55% of tribology research publications were funded by funding agencies. Even though the average number of authors per paper is 19% larger for funded than non-funded research publications, the median number of authors per paper (4) is same for both types of publications. But there is a considerable difference (>300%) in the number of single authored research publications between funded and non-funded. Average number of cited references also differs (17% higher) between funded and non-funded. The number of funded publications without author keywords is fifty percent higher than non-funded research publications.

The year-wise number of funded and non-funded publications with funding ratio and relative funding index is shown in Table 2. Overall 55.5% of research publications were funded. The number of funded research publications has increased dramatically from 2008 onwards. It is observed that in the first two years (2008 and 2009), the ratio of funded publications is lower than the average. It should be noted here that the Web of Science (WoS) has started recording the funding information of publications from August 2008 only.

**Table 1: Bibliometrics characteristics between funded and non-funded**

Characteristics	Funded	Non-Funded
# Publications	6215	4797
Average authors	4.46	3.75
# Single Authored	141 (2.2%)	443 (9.2%)
# ICP	1306 (21%)	699 (14.5%)
Average References	31.72	27
# Papers without Author Keywords	912 (15%)	378 (8%)

**Table 2: Year-wise funded and non-funded research in tribology**

Year	# Funded	# Non-funded	TP	FR	RFI
2008	229	1073	1302	17.59	0.32
2009	689	726	1415	48.69	0.88
2010	838	668	1506	55.64	1.00
2011	856	673	1529	55.98	1.01
2012	997	580	1577	63.22	1.14
2013	1263	672	1935	65.27	1.18
2014	1343	587	1930	69.59	1.25
Total	6215	4979	11194	55.52	

**Table 3: Number of funded and non-funded publications by document types**

DT	#Funded	# Non-funded	TP	FR	RFI
Articles	6100	3878	9978	61.13	1.10
Reviews	113	880	993	11.38	0.20
Article; Proceeding Papers	2	221	223	0.90	0.02
Total	6215	4979	11194	55.52	

**Table 4: Citation impact of funded and non-funded research**

Category	Un-cited %	CPP	CPP / ICP	# HCP (%)
Funded	24.32	5.67	6.18	178 (2.86)
Non-funded	27.96	6.13	7.85	175 (3.65)
Total	25.94	5.87		

The number of funded and non-funded research publications in terms of document type is investigated. Table 3 shows that most of funded research publications in the field of tribology were published as articles. Among the three document types, only articles achieved the higher funding ratio and RFI than average. This implies that arti-

cles are the predominant type of research communication among the funded research community.

The citation impact and un-citedness between funded and non-funded research publications are examined. It is observed from Table 4 that almost 26% of total publications in the field of tribology were uncited. Even though the un-citedness of funded research is lower than the average, the CPP is higher than the average but lower than that of non-funded ones. Similarly, the citation impact of internationally collaborative papers of funded is also lower (almost 27%) than that of non-funded ones. This result is in agreement with the argument by Zhao<sup>[13]</sup> that funded research may tend to the short-term and specific-goal oriented, while normal research allows for more open, long-term, curiosity-driven investigation because researchers do not have the constraints imposed by grant programs. The share of highly cited papers in funded research is also lower than non-funded ones.

## CONCLUSION

This study compared the bibliometric characteristics between funded and non-funded based on the research publications in the field of tribology. The study reveals that there is no difference in the number of authors but big difference in the number of single authored publications. The number of publications without author keywords is higher for funded than non-funded ones. The number of funded publications has increased dramatically from 2008. The articles are predominant type of publications were funded in this research field. In terms of citation impact, funded publications had received lower than non-funded ones. However, the share of international collaborative publications is fifty percent higher for funded than non-funded publications which indicates that higher capability of funded publications with international visibility.

The current study focuses only on differentiate the bibliometric characteristics between funded and non-funded publications; leading funding agencies, funding behavior of countries and impact of funded publications of different countries have not been investigated. These issues will be of potential interest among the scientific community in general as well as funding agencies.

## ACKNOWLEDGEMENT

I thank the anonymous reviewers for their valuable comments and suggestions for improving the manuscript.

**CONFLICT OF INTEREST**

None

**ABBREVIATION USED**

TP: Total Publications; FR: Funding Ratio; RFI: Relative Funding Index; CPP: Citations Per Paper; ICP: International Collaborative Publications; HCP: Highly Cited Papers

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**How to cite this article:** Elango B. Bibliometric Characteristics and Citation Impact of Funded Research: A Case Study of Tribology. *J Scientometric Res*. 2017;6(1):47-50.