Semantic Evaluation and Identification of Academic Representative Papers

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Abstract. Academic papers are the main output and important knowledge carrier of scientific activities. They have the functions of knowledge flow, diffusion, and transfer. Academic representative paper is very significant to funding project review, talent introduction and institutional evaluation. These existing evaluation methods focus on external features or quantitative indicators based on paper citations. It is insufficient evaluation to semantic content features. In the paper, we draw on the theory of scientific values and design evaluation framework that include two dimensions, namely usage scale utility and knowledge utility of papers. Usage scale utility is reflected in the citation and download usage of the paper by peer scholars and mainly measured with quantitative indicators. The knowledge utility is reflected in the cited content role and mainly measured with semantic content analysis. We propose comprehensive evaluation method and value hierarchy system based on usage scale utility and knowledge utility dimensions. It can assist users to discover and focus on representative academic papers quickly.

Keywords: Academic Representative Papers, Semantic Identification, Semantic Measurement.

1 Introduction

Representative works refer to the achievements that are best to reflect the research ability, academic level, and value contribution of the evaluated object. Representative works are various in different disciplines, technologies or fields, which can be a single achievement such as a paper or a funding project or a complete set of achievements such as a series of papers or a group of patents. Representative works are dynamically changing with the researchers' career. At present, representative works evaluation is widely used in funding project review, talent introduction, institutional evaluation or award evaluation. Academic research papers are the main output and important knowledge carriers of scientific activities and contain rich semantic content. They have the functions of knowledge flow, diffusion, and transfer and they are the important power for scientific and technological innovation and communication. With the increasing of papers, how to identify representative and highly influential papers of a specific field, institution or researcher from massive resource gained more and more attention. It is urgent to improve the scientific research evaluation indicators or methods

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on the quality, contribution and impact of the academic representative papers. In the era of big data and artificial intelligence, it is a common expectation and research focus on quickly identifying representative papers from the perspective of semantic content using mature technologies such as natural language processing and text mining.

2 Related Research

The academic representative papers evaluation has become a mature scientific and technological system in foreign countries. Research Excellence Framework（REF）in UK measures researchers with high quality publication[1] and the university of Southern California evaluates scientific papers from authority, usefulness and reliability dimension[2]. Scholars have explored various evaluation methods or indicators for academic representative papers based on citation analysis and semantic content. Zeng proposed to identify representative papers from scientific nature, innovativeness and value dimension[3]. Wang Z evaluated innovation of scientific literatures on the basis of knowledge elements analysis[4]. Bibliometric indicators are the common and simple methods to evaluate academic papers impact based on citation analysis, for example, citation frequency, citation half-life, journal impact factor and so on. Zhou J proposed to use the maximum gap in a histogram of a scientist's sorted papers' citation counts to classify his or her papers into representative papers and regular papers groups[5]. Zhang Y constructed a heterogeneous bibliometric weighted network based on citation relevance and author contribution to rank scientific papers[6]. Le X designed evidence-based evaluation tool CiteOpinion for evaluation academic contributions of research papers based on citing sentences[7]. Bornmann L proposed bibliometric novelty indicators and verified effectiveness based on F1000Prime data[8]. Reinald KA presented novelty detection model based on autoencoder neural network which combined authors and documents macro-level graphs and keywords and topics micro-level graphs[9]. Zhang X proposed a graph autoencoder framework based on heterogeneous networks for the measurement of paper impact and the framework constructed a heterogeneous network of papers, institutions, and venues and simultaneously analyzed the semantic information of papers and the heterogeneous network structural information[10].

The quantitative evaluation methods neglect the quality of semantic content which lead to excessive emphasis on external indicators. Machine learning and semantic mining technologies provide technical support for automatic understanding of text content. But now most research on semantic content evaluation focus on some specific knowledge points or innovative sentences analysis. On the basis of the bibliometric and semantic content evaluation, we explore comprehensive evaluation model combining quantitative indication and semantic content.

3 Methodology

Scientific value theory divides the value of things into behavioral utility value and knowledge utility value. So we measure value of academic papers from usage scale

utility and knowledge utility based on scientific value theory. Usage scale utility is reflected in the number of paper citations and use/downloads by peer scholars. The knowledge utility is reflected in the role of quoting sentences in citing papers. The citation effectiveness gained from full text analysis of citation, including quoting sentiment, citation positon and citation motivation analysis. And then we design paper hierarchy according to usage scale utility and knowledge utility and assist users to discover and focus on academic representative papers in some specific field quickly. The research framework is shown in Fig. 1.

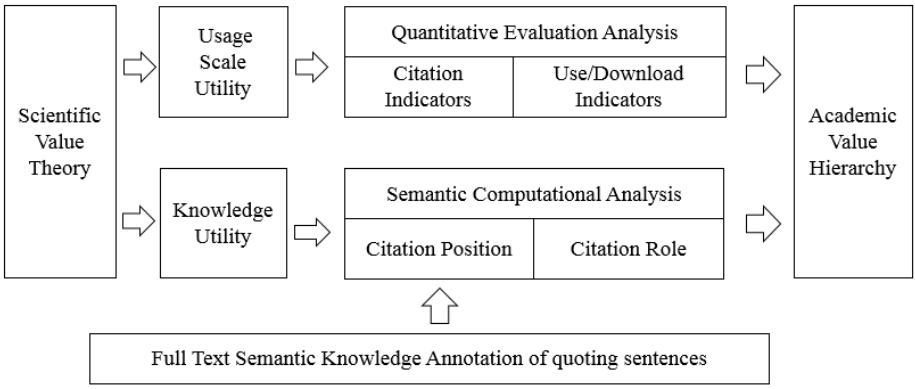

Fig. 1. The proposed research framework

Usage scale utility is mainly measured by quantitative method and the indicators include the number of citation, usage or download. Knowledge utility is mainly measured by semantic computational analysis of citing sentences and the indicators include citation position and citation role. The indicators are shown in Table 1. According to structure of academic papers, the citation positions are subdivided into four types, such as introduction, data and method, experiment results and discussion. The citation in results and discussion positions are more important than citation in introduction and data and method positions. Citation roles are based on the author's intent. We reference to citation classifications in web of science database and classify citation role into five types, namely background, basis, support, differ and discuss. Background role refers to previously published research that orients the current study within a scholarly area. Basis role refers to the data sets, methods, concepts and ideas that the author is using for her work directly or on which the author bases her work. Support role refers to similarities in methodology or in some cases replication of results. Differ role refers to differences in methodology or differences in sample sizes, affecting results. Discuss role refers to that the current study is going into a more detailed discussion. The indicators are shown in Table 1.

Table 1. Usage scale utility and knowledge utility indicators

Dimension	Method	Indicators	
		Citation Frequency	Total Citation Frequency

Usage Scale Utility	Quantitative Analysis		Annual Average Citation Frequency
		Use/Download Frequency	Total Use/Download Frequency
			Annual Average Use/Download Frequency
			Use/Download Frequency Within the Past Six Months
Knowledge Utility	Semantic Computational Analysis	Citation Position	Introduction
			Data and Methods
			Experiment Result
			Discussion
		Citation Role	Background
			Basis
			Support
			Differ
			Discuss

According to the quartile method, we divide academic papers into four levels based on both usage scale utility and knowledge utility dimension. The hierarchy is a pyramid shape and includes milestone papers, leading role papers, important role papers, and foundational role papers based on academic value from high to low. The proportion of milestone papers and leading role papers are relatively low in pyramid hierarchy. While important role papers and foundational role papers are relatively high. The first level of milestone papers corresponds to the papers in the first quartile of both usage utility scale and knowledge utility dimensions. The second level of leading papers corresponds to the papers in the second quartile and the third level of important papers corresponds to the papers in the third quartile and the fourth level of foundational papers corresponds to the papers in the fourth quartile. The pyramid hierarchy is consistent with the laws of scientific development and the evaluation mechanism. The details are shown in Fig. 2. The milestone papers and leading role papers are the representative works.

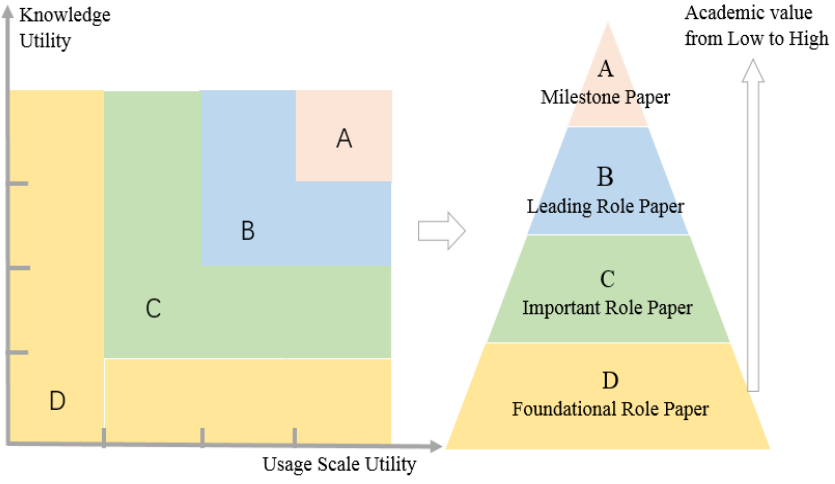

Fig. 2. Academic papers hierarchy based on usage scale utility and knowledge utility

4 Experiments

Nobel laureates' papers are generally considered to be highly influential papers and their usage scale utility and knowledge utility are higher than ordinary papers in the same field. They are usually at the milestone paper level or leading paper level. In this paper, we take Nobel laureates' papers as high-influence papers group and compare with other papers in the same field and verify the feasibility and scientific nature of evaluation method and hierarchical system.

4.1 Dataset Description

American scientist David Julius was awarded the Nobel Prize in Physiology or Medicine in 2021 and he discovered TRPV1 receptor. We search Web of Science database for papers on TRPV1 receptor research by using the keyword of TRPV1 receptor. In order to ensure that the papers have more than three years of citation window and avoid the impact of Nobel awards, the papers were published until 2020. We retrieved 5528 papers, of which 21 papers were published by David Julius.

4.2 Experimental results

The correlation among indicators are strong in the usage scale utility and knowledge utility dimension respectively. Principle components analysis (PCA) method can transform multiple indicators into a few principal components with minimal loss of information based on dimensionality reduction idea and also use the variance contribution rate of each principal component as weight which avoid subjectivity caused by manual assignment weight. We use PCA method to calculate the value of usage scale utility and knowledge utility for each paper. The value distribution of usage scale utility and knowledge utility is shown in Fig. 3. The usage scale utility value and knowledge utility value of most papers are both low. We can see most paper in experiment dataset are in the bottom of the pyramid hierarchy and belong to the foundational role papers and only a very small number of papers in the top of the pyramid hierarchy and belong to milestone or leading role papers.

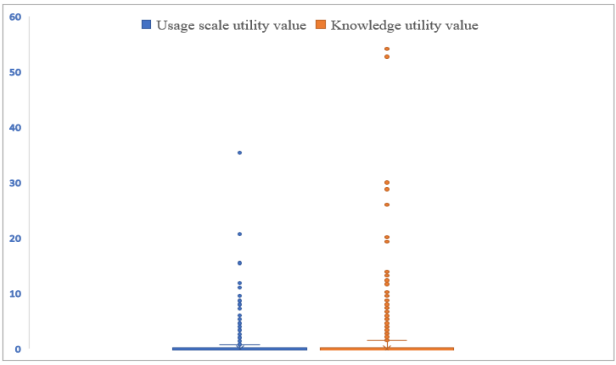

Fig. 3. Distribution of usage scale utility and knowledge utility values

From Fig. 4, we can see that the 21 papers of TRPV1 receptor research (marked by red dots) published by Nobel Laureate David Julius have much higher usage scale utility value and knowledge utility value than other papers in the same field. They are at the top of the pyramid hierarchy and belonging to the milestone or leading role papers. The experimental results show that the representative paper evaluation method and the hierarchy can distinguish highly influential papers in TRPV1 receptor field.

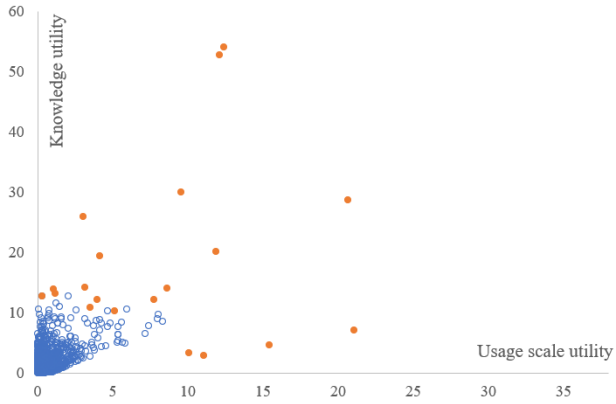

Fig. 4. Usage scale utility and knowledge utility of Nobel laureate papers (Red dots represent papers published by Nobel laureates)

More than 72 % of papers in TRPV1 receptor dataset are at foundational role paper level. The 9 papers of Nobel laureate David belong to milestone or leading role papers, accounting for 43% of his 21 papers. The number of papers at different levels corresponds to pyramid hierarchy. Detailed distribution of papers is shown in Table 2.

Table 2 number of different levels paper in pyramid hierarchy

Hierarchy	Total number of Papers	proportion of each level paper
Milestone Paper	6	0.11%
Leading Role Paper	56	1.01%
Important Role Paper	1433	25.92%
Foundational Role Paper	4033	72.96%

Most of Nobel laureate's papers in TRPV1 receptor dataset have higher usage scale utility value and knowledge utility value. The experiment verifies that the evaluation method based on usage scale utility and knowledge utility can measure the value of papers. The pyramid hierarchy can identify and distinguish highly influential papers from academic papers dataset and assist user to focus on academic representative papers in different field in short time. But the evaluation indicators ignore the influence of citation interdisciplinary and we will further optimize the evaluation model and value hierarchy. In this paper, we only choose small-scale experiment dataset to verify the scientificity and effectiveness of evaluation model and pyramid hierarchy and will further expand dataset in in different research fields.

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