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CITATION FUNCTIONS AND RELATED DETERMINANTS: A STUDY OF CHINESE PHYSICS PUBLICATIONS

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ABSTRACT

The purpose of this study was to examine various factors which may explain the nature of document usage in the scientific citing process. Different from most citation studies, this study used a direct questioning method to approach the problem. The Chinese physicist authors were asked to identify their purposes of citing and the functions of each reference they cited in the article. As a result, multiple functions of a citation, and their relations to citing motives were found. The results were compared with other related studies. It concluded that citing is not a straight-forward process, rather it is motivated by multiple factors.

Introduction

Citing is the process of using other people's works as references in one's own writing. The practice of citing references by scientists has attracted attention from scientists, science historians, sociologists, psychologists and information professionals for a long time, but it was not until the 1960s that citations became the subject of extensive studies, known as citation analysis. The development of new techniques and measures (i.e. citation counts, bibliographic coupling and co-citation analysis), the emergence of tools, such as *Science Citation Index* and *Journal Citation Report*, and the study of different units of analysis, have led to a rapid growth in both the number and type of studies using citation analysis. Numerous studies on journal evaluation, publication productivity, and communication patterns have been published.

Although citation analysis has been widely used, Small has noted that most of the studies have assumed that all cited papers were equal in terms of their usage.¹ Other critics have questioned both the assumption and methods of these studies. The major critique was that while counting an author's citation numbers, the analyst ignored the underlying purposes of why an author cited them. The purpose of selecting citations may involve scientific, political and personal goals other than describing intellectual ancestry.²

Gilbert proposed an alternative theory of citing which considers scientific papers as "tools of persuasion."³ Cronin conjectured that referencing behavior is the result of the citer's perceptions, attitudes, prejudices or erudition.⁴

If citations are not equal, are there different functions of each cited paper? If there are different functions, how do they relate to authors' citing motivation? Over the years, a number of attempts have been made to answer these questions. In terms of methodology, two approaches have been explored: functional classification of cited documents and citer motivation modeling. Functional classification studies have tried to devise a classification or taxonomy based on a text analysis in order to find out the inter-document relationship in the presence of reference citations, while citer motivation model studies have tried to identify significant citer motives by surveying the authors themselves.

Literature Review

Functional classifications have been approached by Magee, Spiegel-Rosing, Peritz, Moravcsik and Murugesan, Chubin and Moitra, Hooten, Cano, and Oppenheim and Renn. Magee used a classification scheme for information needs of scientists and the ways they used the information they had found in the published sources. Spiegel-Rosing, in an analysis of the first four volumes of *Science Studies*, devised 13 categories for content analysis of citations found in these volumes. Peritz proposed a refined scheme of the manifest functions of citations for substantive-empirical papers. In a series of studies, Moravcsik and Murugesan attempted to go one step further by analyzing the quality of citations and the contexts in which citations were made. They developed a non-dichotomous typology by classifying citations according to their functions. This typology consists of four dimensions:

- 1) Conceptual or Operational
- 2) Organic or Perfunctory
- 3) Evolutionary or Juxtapositional
- 4) Confirmative or Negational⁵

As a result, variations in the nature of citation measures within journals and scientific specialties were found. A large fraction of the references were found perfunctory which raised doubts about the use of citations as a quality measure.

An alternative model to this typology is the one proposed by Chubin and Moitra. This model is a six-class citation typology. It distinguishes affirmative citations from negative ones, essential from supplementary, and basic from subsidiary:

Type 1	Affirmative -- essential -- basic
Type 2	Affirmative -- essential -- subsidiary
Type 3	Affirmative -- supplementary -- partial
Type 4	Affirmative -- supplementary -- total
Type 5	Negational -- partial
Type 6	Negational -- total ⁶

By applying this typology to a sample of articles in high energy physics, Chubin and Moitra found that citation practices varied by form, content, and outlet of the articles.

In an attempt to examine factors which may explain frequency and nature of use of documents in citing document texts over time, Hooten utilized a combination of four classification taxonomies developed by Murugesan and Moravcsik, Peritz, Chubin and Moitra, and Spiegel-Rosing to approach the problem. She found that frequently cited documents were more essential than infrequently cited ones, and that they were also used at a stable higher level over a longer period of time.

Cano tested the citation behavior model of Moravcsik and Murugesan and examined the hypothesized relationships among three variables: citation type, utility level, and citation location. Cano's findings contradict the notions of discreteness and equality of value of citations held by citation analysis. The empirical data suggest that a document may contain many items of information that may be cited for a number of reasons.

In Brooks' study, for the first time a sample of authors were surveyed and their motivations in giving references were assessed. Seven motivational scales were identified. Brooks found persuasiveness appeared to be the major motivator.⁷ In a further study, he found that the majority of the references were attributed to more than one motive.⁸ His assessment of the complexities of citer motivations agrees with Cano's findings.

Vinkler developed a citation model by categorizing citations into two major groups: professional function and connectional function. Professional functions were found to be the predominant reason for citing. Among professional functions, documentary, applicational, and confirmative functions were playing important roles in an author's citing practice, with documentary rated the first, applicational the second, and confirmative the third. Finally, Vinkler confirmed his own assumption that "the citation threshold depends primarily on the professional relevance of the work potentially citable in the given paper."⁹

All these studies have provided evidence that citations are not treated equally and that citing is a complex process. However, empirical research of citation functions has still been inadequate, and knowledge of the elements implicit in the citation process is very limited. The purpose of this study is to

further explore the functions of cited references and their relationship to scientists' citing behavior.

Methodology

Different from the methods employed in previous citation studies which imposed too much of the researcher's personal judgement, this study utilized a survey method by which data were collected from the answers to direct questioning--"the most sensible methods of trying to penetrate [the] private world" of studying the citation process.¹⁰

This research is mainly concerned with Chinese scientists who are actively involved in scientific studies and research publications. Due to the large size of China's scientific population, this investigation limits itself to a specific field of science--physics. The population of the citing authors considered in this study were those whose published research articles were selected by *Chinese Physics*, a quarterly journal published by the American Institute of Physics as a secondary source. *Chinese Physics* contains English translations of research articles selected by the Editorial Board from 14 leading Chinese language physics journal. This source journal was selected for its authority and representation of current Chinese physics research. Among 973 published articles from 1981 to 1987, 725 articles/authors were identified on the basis of citation availability and single occurrence of the article.

Using questionnaires as the data collection instrument, this study intended to find out the citation functions and their determinants by studying the citations attached by an author to a published paper. Each item of the cited reference was examined in full detail in terms of its cited purposes. In the questionnaire, each author was given a list of suggested reasons why a particular citation was chosen and asked to check the suggestion most closely related to his/her own. The suggested reasons of citing included:

- To provide historical background and review;
- To provide theoretical foundation;
- To provide practical method or research data;
- To give supporting facts;
- To compare with own work;
- To argue a different opinion;
- To provide supplementary information;
- To show substantial research work of originality and continuity;

The authors were also asked to what extent they were influenced by the internal and external factors in selecting reference citations:

- To demonstrate familiarity with the research area;

- To persuade the scientific community;
- The editorial policy encourages references;
- The scientific community values references;
- The author or the paper is eminent in this area;
- The author influenced one's career;
- The journal is prestigious;
- To provide more up-to-date information.

Included in the questionnaire package sent to each author were a copy of the questionnaire, the title page of the article selected, and the citation page(s) of the articles. Of the 725 questionnaires sent 415 responses were received, representing a total response rate of 57.2%.

Findings

1. Multiple Use of Citation Functions

Although there were only 4,025 references cited by the respondents in this survey, 5,899 citing purposes were identified. Apparently some citations may carry more than one purpose. A calculation of means shows that each reference has an average of 1.5 citing purposes. Table 1 lists nine citation purposes and the distribution of citations. Table 2 lists an array of citations with a corresponding number of purposes. While 41.1% of references have only one citing purpose, 32.9% or a third of them have two purposes, 15% of the citations had three purposes and 9.7% carry four or more. This finding has confirmed Cano and Brooks' results that a number of reasons may be involved in one cited reference. This, again, demonstrates that citing is not a straight-forward process, but is motivated by multiple factors.

Table 3 shows that historical and practical are the two leading functions which are more likely to be present with other functions. Since historical citations hold the highest percent rate, it is not surprising that it pairs with many other functions. Practical citations, although representing only 8.5% of the total, were very frequently paired with other functions. It is also interesting to see 25 instances with both supportive and negational functions. Different interpretations of supportive and negational could be the reason for this opposing combination. More importantly, the co-existence of the opposite functions in one citation could represent an author's mixed opinion.

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Citing Purpose	Number of Citations	Percentage (%)
Historical	1692	42.0
Comparative	1082	26.9
Theoretical	996	24.7
Supportive	762	18.9
Substantial	530	13.2
Supplementary	349	8.7
Practical	342	8.5
Negational	109	2.7
Other	37	0.9
TOTAL	5899	

Table 1. Distribution of Citation Purposes

Number of Purposes	Number of Citations	Percentage (%)
1	1654	41.09
2	1324	32.89
3	605	15.03
4	262	6.52
5	87	2.16
6	30	0.75
7	10	0.25
8	2	0.04
9	1	0.02
0	50	1.24
TOTAL	4025	100.00

(Note: Percentage was calculated based on 4025 surveyed references.)

Table 2. Number of Citation Purposes vs. Number of Citations

2. Citation Functions and Related Determinants

In order to examine how citation functions are related to internal and external factors, regression tests were performed by using citation functions as

dependent variables and internal/external factors as independent variables, such as familiarity, persuasion, journal reputation, editorial policy, value perception, career consideration, currency, and author reputation. As a result, three internal factors were identified to be related to citation functions. Table 4 shows that there were significant relationships between: 1) familiarity and historical citations, 2) journal reputation and theoretical citations, 3) journal reputation and practical citations, and 4) persuasion and substantial citations.

Citation Functions	Number of Cited Documents	Percentage (%)
Historical and Comparative	472	11.72
Historical and Substantial	408	10.14
Historical and Practical	397	9.86
Practical and Comparative	370	9.19
Practical and Substantial	322	8.00
Historical and Supportive	309	7.67
Practical and Theoretical	304	7.55
Historical and Supplementary	292	7.25
Practical and Supportive	280	6.96
Practical and Supplementary	203	5.04
Supportive and Negational	25	0.62

Table 3. Paired Citation Functions

Dependent Variable (n=272)	Independent Variable (r<.05)	r	SE	df	r ²
Historical	Familiarity	.12	.26	271	.015
Theoretical	Journal Rep.	.22	.19	226	.048
Practical	Journal Rep.	.25	.14	226	.064
Substantial	Persuasion	.16	.16	271	.026

Table 4 Stepwise Regression of Internal Factors on Citation Functions

Citations with historical functions represented the largest proportion (42%) among all the eight functions. They were paired most frequently with comparative, substantial and practical functions. A stepwise multiple

regression picked up familiarity as the predictor of historical citations, which suggests that the more an author wanted to demonstrate scientific knowledge in his research field, the more he would review articles and cite references with historical background information.

Comparative citations represented the second largest proportion (26.9%) out of the eight functions. They are often paired with historical and practical citations. No patterns were found to explain why they were thus paired. Neither did multiple regression show any significant relationship between comparative citations and motivation factors.

Theoretical citations represent 24.7% while practical citations represent only 8.5% of the total citations in the surveyed papers. Journal reputation appeared to be a decisive factor affecting the cited sources with both theoretical and practical functions. This suggests that, during the process of selecting reference citations, the more respectable an author considered a journal to be, the more likely he was going to select references with theoretical or practical functions from that journal. Although both functions are affected by journal reputation, practical citations were less frequently cited than theoretical ones. One may speculate that well-respected journals may carry more articles written about physics theories than papers with practical information and journals carrying information about theoretical research are more respected than those carrying practical studies.

Citations with substantial functions received moderate presentation (13.16%) among all the citations. Substantial function was often paired with practical function. This may suggest that in order to demonstrate an author's originality and continuity of a particular research he needed to use practical information to support it. Persuasion was found related to the proportion of substantial function. The findings suggest that the more an author was motivated to persuade the scientific community to agree with him, the more he would select references that could demonstrate his originality and continuity.

Supportive citations represented 18.9% of the total citations and were often paired with citations with historical and practical functions. Obviously, when an author wanted to demonstrate facts to support his ideas, he was more likely to use reference items with historical overviews or practical methods to achieve his purpose. No factors were found to be related to supportive citations. Negational citations represented the least proportion (2.7%) of the total citations in the surveyed articles. No factors were found to be related to negational citation.

Category	Morave.	Chubin	Cole	Speig.	Oppen.	Frost	Finney	Vinkler	Liu
Refuted (negative)	14%	5%	6%	1%	2%	14%	5%	5.2%	2.7%
Noted only (perfunctory) (Documentary)	41%	20%	24%	20%	60%	38%	33%	51%	50.6%
Reviewed (compared)	40%	32%	-	16%	13%	22%	-	-	26.9%
Applied (utilized)	60%	43%	36%	11%	28%	1%	29%	57%	42.8%
Supported (substantiated)	-	-	18%	47%	-	22%	-	16%	32%

706 references in high energy physics (Moravesik and Murugesan, 1975).

443 references in high energy physics (Chubin and Moitra, 1975).

123 references to paper by Robert Merton (Cole, 1975).

14,245 references in *Humangenetik* (Spiegel-Rosing and Schwidetzky, 1976).

978 references to old physical science papers (Oppenheim and Renn, 1978).

References from approximately 60 German literary research articles (Frost, 1979).

1,115 references in post-natal mood change articles (Finney, 1979).

484 references in chemistry papers by Hungarian chemists (Vinkler, 1987).

4,025 references in physics papers by Chinese physicists (Liu, 1990).

Table 5. Comparison of Reference Classifications

Comparisons

In order to compare the findings of this study with the results of previous studies about citation patterns of American scientists, especially those focusing on physicists or physics publications, a juxtapositional table is made based on Small's comparison table. Small made a quantitative comparison of reference classifications of seven studies.¹¹ Vinkler's study was not included because it was published later. Table 5 shows the comparison of the findings of this study with these seven studies plus Vinkler's.

As Small stated, the data sets identified here vary from physical science and medicine to social science and humanities. It is possible to compare these studies for only certain categories. Therefore, this researcher's data have been altered to fit this table. For example, supplementary and historical citations are combined and fit in Small's category "Noted only (perfunctory)", practical and theoretical are combined into the category "Applied (utilized)", and supportive and substantial are combined in "Supported (substantiated)". Comparative and negational readily fit Small's table as "Reviewed" and "Refuted", respectively.

From Table 5, one can see the "Refuted" citations vary from a low of 1% to a high of 14%, with Liu's finding ranking the third lowest. The "Noted only" category consistently captures the largest fraction of citations which has been proved in Liu's study. With 50.6% of "Noted only" citations, Liu's finding ranks second in this category. Comparative citations spread quite evenly in each study. All physics literature shows high scores in the category of "Applied (utilized)", including Liu's finding, which is a little lower than Moravcsik and Murugesan's, Chubin and Moitra's, and Vinkler's, but higher than the findings in all other studies. Only Spiegel-Rosing's study showed a moderately high percentage in the "Supported (substantiated)" category, while four studies did not even include this category.

On the whole, there are no significant differences between Liu's findings and the other studies. In fact, the studies on physics literature show more similar results than in the other disciplines. However, Liu's study not only deals with the proportion of citations in different citation categories, but also goes one step further in investigating the possible causes of the phenomenon.

Conclusion

The research reported here was an exploratory study of the citation practice of Chinese scientists in their selection of reference citations. It employed a non-traditional methodology--direct questioning--to approach the problem of citation function and citing factors. Because it is exploratory in nature, an exploratory statistical technique was applied in the study to test the

significance. These statistical analyses were treated in such a way that would enable the researcher to look at the results together rather than making strict statistical claims. Therefore, there might be some limitations to draw a generalized conclusion as to Chinese physicists' citing practice. However, this exploratory study has achieved new insights into the scientific citation process and suggested premises for further studies.

A scientist's citing process is complicated. This study suggests that evidence of complex citation functions indicate that one reference citation may be attributed to more than one purpose. Overall analyses found that citation with historical, comparative, theoretical, and supportive functions were frequently cited, whereas citation with supplementary, practical, and negational functions were less frequently cited. Factors, such as journal reputation, the motive of showing one's knowledge, and the desire to persuade others all play roles in the citation process.

This study is an initial attempt to explore the underlying norms in the citation process in the Chinese scientific community. Further studies are needed to investigate the complexities of this process. The contribution of this study lies in its unique, non-traditional approach to the problem of the citation process. This methodology of direct questioning of the citing authors can be applied to other scientific disciplines and in other countries, and with little modification, to the humanities as well. Therefore, the significance of this pioneer study has gone beyond the discipline of physics and beyond the boundaries of China.

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