

# The Citedness of a Scientific Paper Written/Published in a Scientifically Peripheral Country by Worldwide Science Literature: The Case of Korea

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## 초 록

본 연구는 학문적으로 주변 국가인 한국에서 출판된 과학 학술잡지 또는 한국 과학자의 인용성에 대해 조사하였다. 실험결과, 한국에서 출판된 과학 학술잡지 또는 과학자에 대한 외국 학자들의 인용빈도는 매우 낮은 것으로 나타났다. 따라서 한국의 과학 또는 한국 과학자의 세계적 학문에 대한 공헌도는 매우 낮은 것으로 결론 내릴 수 있으나, 학문적 주변국가의 과학자 또는 그곳에서 출판된 잡지는 그 나름대로의 가치를 지녔음을 인정하여야 할 것이다.

## ABSTRACT

This study attempts to determine the citedness of a scientific research paper written/published in Korea, one of the scientifically peripheral countries and the citedness of a Korean scientist in mathematic and chemistry. It was found that there is a negligible proportion of citations in papers by foreign scientists to scientific literature from Korean and Korean scientists. Thus, it can be true that Korean science or scientists make a relatively small contribution to world science; however it is also true that the peripheral journal has its own scientific value for local area.

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## I. INTRODUCTION

### 1.1 Research Background

An essential part of research papers, particularly in science, is the list of references pointing to prior publication (Smith, 1981). The use of references in a paper is often taken as an indication of the scientific value of the paper and has even been considered to be a criterion of its "scientificity" in legal disputes (Hierppe, 1978). The references that tie together the papers of scientific literature into networks perform several different functions and can be used for a large number of purposes. Quantitative analyses of the references of scientific literature and citation networks have been utilized to illuminate many aspects of science and research.

Citation analysis especially, which began about sixty years ago, is a widely accepted research method and has been used successfully in several areas. Citations to a document are understood to be indicative of its influence on the research reported in the citing papers (Griffth, et al., 1974). Citation counts have tended to be a reliable indicator of the quality of scientific output, to the extent that citation counts could be considered a measure of scientific progress and not simply of productivity (Moravcsik, 1973).

Citation analysis, however, is not without its problems, even though it has rapidly grown in popularity. Attention has been called to the fact

that little is known about how scientists decide to cite papers in their work and why they choose to cite particular papers rather than others. In particular, when the use of citation is extended to assess scientific output in countries where scientific publication is peripheral, a number of additional problems emerge because social factors play a role in shaping citation patterns (Velho, 1986). In two separate studies, those of Irvine and Martin(1985) and of Murugesan and Moravcsik(1978), it was found that the same specialities in different countries often have a different citation rate. Lange's study(1985) reported that preferred language of the cited publication and absolute citation frequency were dependent on discipline and country of publication.

Velho(1986), who surveyed citations of Brazilian agricultural research, reported that the citation patterns are significantly influenced by external factors such as language barrier, difference in accessibility of scientific literature from peripheral and advanced countries, and the education history of scientists working in peripheral nations. Thus, she concluded that citation counts based on international databases such as those of ISI simply cannot be taken as valid indicators of the quality, influence or impact of published scientific knowledge. Moreover, on any given subject, peripheral publications are undercited in advanced countries as compared to worldwide publications. Using the same survey results,

Moravcsik(1987) reached the opposite conclusion to that of Velho on the basis that the measure Velho applied was not valid. Moravcsik maintained that in order to reach any conclusion about the rate of citation of peripheral publications by researchers in advanced countries, one has to use ratios of citations to publications rather than absolute numbers of citations in making the comparisons. This, for example, requires knowledge of the total number of agricultural papers published in Brazil and the number of agricultural papers published worldwide. In the absence of such knowledge, Moravcsik used the total number of citations in papers written in the Third World countries and the total number of papers coming from the Third World. Based on Velho's data, Moravcsik concluded that a given paper written in a developing country has as good a chance to be cited by the worldwide scientific literature as does any other scientific paper.

This is a surprising conclusion, since scientists in both advanced countries and less developed countries seem to tend to cite worldwide scientific literature published in the journals of advanced countries. Scientists in less developed countries may choose to publish their articles in internationally recognized journals in order to have wider exposure and readership, and hence have a better chance of being cited by scientists worldwide. Therefore, these controversial studies concerning journals published in scientifically peripheral countries have raised the question of

what the citation pattern of the literature of advanced countries to those journals is. What citation pattern to journals published in scientifically peripheral countries exists? Is there any difference in the citation pattern to its counterpart in scientifically advanced countries? Is there any self-citing pattern? How quickly do papers published in scientifically peripheral countries get cited? Each of those questions brings to mind other queries until one is confronted with a whole series of questions about the citation analysis of journals published in scientifically peripheral countries. This, then, will be the focus of discussion of the present study.

## 1.2 Research Questions

The primary purpose of the study is to determine the citation pattern of worldwide science literature to scientific research papers written/published in a scientifically peripheral country (SPC) and to SPC scientists. Specifically, it is designed to examine the following research questions concerning the characteristics of citation analysis:

1. Does a science paper written/published in an SPC have the same chance to be cited by worldwide science literature as does any other science paper?

2. Does a science paper written/published in an SPC and covered by Science Citation Index (SCI) have a greater chance of being cited by

worldwide science literature than one not covered by SCI?

3. Do scientists in an SPC who publish their science paper in peripheral journals have the same chance to be cited by worldwide science literature as do those who publish their papers in worldwide journals?

4. Who cites a science paper written/published in an SPC or SPC scientists? To what extent do scientists in an SPC cite their previous publication?

5. How quickly does a science paper written/published in an SPC get cited by worldwide science literature?

### 1.3 Assumptions and Limitations

There are three assumptions for this study. First, it is assumed that the number of times a document is cited is directly proportional to its value or intrinsic worth. Second, it is assumed that data selection from 1984, 1985, 1986, 1987, 1988, 1989, and 1990 editions of Science Citation Index are sufficiently accurate to provide credibility to this study. Third, it is assumed that the representative journals selected give an accurate view of the relative use of scholarly articles by research workers.

Since this investigation was undertaken with the objective of studying mathematical and chemical journals published in a scientifically peripheral country (Korea) in its present state, sampling was limited to a small number of major

national journals in each field. Hence, the generalizations in this study are limited by the following factors:

1. Citation analysis only in the field of mathematics and chemistry.

2. Mathematical and chemical journals published in Korea only.

3. The citations made by worldwide science literature for a five-year period after the publication of the source journals used.

## I. LITERATURE REVIEW

Different countries of the world are at different stages of scientific development (Arunachalam & Markanday, 1981). Scientific output, which participates in the creation of scientific knowledge, is one of the elements representing the development of a country. Many studies, thus, have attempted to find each country's contribution to scientific knowledge and to develop certain indicators to characterize the scientific output of a country. In particular, these studies have concentrated on measuring the extent to which scientist in that country contribute to growth of scientific knowledge and on comparing each country's contributions in any given field to that of other countries.

From the point of view of scientific productivity, it will be profitable to classify the countries of the world into three groups: mainstream countries; peripheral countries (or the Third World); and middle-level countries

(the latter lying between these two extremes) (Arunachalam & Markanday, 1981). This chapter discusses the relevant studies defining the characteristics of research papers published in scientifically peripheral countries (SPC's) including Korea.

### 2.1 Science in Scientifically Peripheral Countries (SPC's)

Studies on "SPC science" are still few and far between in spite of the growing interest in this topic in recent years. The lack of specific studies on any individual country (especially in the SPC category) means that most of what is known on the subject does not go much beyond educated guesses or broad generalizations (Spagnolo, 1990).

Generalization about quality of research papers published in SPC's focuses on deviations from accepted international practices relating to the operation of scientific journals, the selection of research topics, and the communication of research results (Davis & Eisemon, 1989). It is frequently claimed that a high proportion of scientific journals in SPC's are not refereed and that SPC research is not significant or creative. A study of rejected scientific papers finds that 44% of those originating in SPC's are judged unoriginal, and that in one-fifth of the cases referees object to the poor quality of the references (Gordon, 1979). Thus SPC science is considered to be mediocre, or, as Davis and

Eisemon indicate, SPC journals are "a vast forum for mediocrity."

Christovao(1985) explained that this characteristic is caused by the differences in the communication system (or the research system) of science in developed countries versus SPCs. Research system in developed countries are characterized by a high degree of cohesion and integration, made possible by a dynamic communication system, whereas research systems in SPC's, in general, present the opposite characteristics, where there are small groups of scientists working in specific scientific areas. Interaction among local research centers is less than the exchange maintained in developed countries. There are inadequate local infrastructures for research and communication, and a lack of local competition for outlets of research. Moreover, scientists in SPC's suffer from the language barrier, the distance of many from metropolitan intellectual centers, and the practical difficulty in communicating with colleagues in scientifically more advanced countries(Eisemon, 1985). Therefore, the foregoing difference of the communication system of science, as well as the individual features which characterize any given country, create the difference of scientific output.

One of the characteristics of SPC science is "isolation," which can be characterized by low international visibility, low participation in invisible colleges, and "disciplinary insularity," which means the absence of any consequential

interaction between disciplines. Arunachalam and Manorama(1988) noticed that in general Indian journals quote a disproportionately large number of papers published in Indian journals, thus neglecting the cross-fertilization that is possible through the inclusion of work reported elsewhere. They add that "this is a characteristic feature of peripheral journals as well as science on the periphery." In many cases, the absence of a mass of criticism and of a strong infrastructure leads the scientist to isolation (Lomnitz, et al., 1987). Arunachalam and Markanday(1981) figuratively described the "isolation" phenomenon as an intellectual "island effect," not receiving and assimilating knowledge from abroad, resulting in "disciplinary insularity" as "an island within an island."

SPC scientific publications are conventionally portrayed as parochial: that is, they do not attract authors from other countries. For example, most Korean journals publish few foreign manuscripts. Davis and Eisemon (1989) reported that authors affiliated with Korean institutions made up 99% of all references in the Korean journals studied. And very few foreign authors publish in Korean non-mainstream journals. Carpenter and Narin (1980) noted that only 5% of the papers in SCI-covered journals published in India are authored by scientists outside of India, whereas 64% of India-authored papers in the SCI appear in journals published by other countries. However, 25% of the papers in U.S. mainstream journals are authored by

scientists in other countries, while only 18% of U.S.-authored papers are published in foreign journals. Even SPC journals considered to be mainstream may also display features of parochialism. According to Arunachalam(1985), only about 5% of the articles published in the Indian Journal of Biochemistry and Biophysics are produced by authors from outside the Indian scientific community. This may be typical of many SPC journals, and suggests that what appears in them is primarily of local significance and importance.

When the SPC papers deal with problems of local significance, they are less suitable for presentation in international journals and also for scientist in other countries. Yuthavong(1986) reported that 28% of all papers appearing in journals which have a significantly international character are contributed to by foreign researchs partially or completely, while the journals which deal with local problems are almost completely devoid of foreign contributors.

Another significant characteristic of local journals published in SPC's is their relatively low cognitive contribution to the mainstream of international research activity. It has frequently been found that non mainstream SPC science is virtually invisible to mainstream science. If worldwide literature cites locally published research, this is taken as recognition of the significance (or quality) of local science. Garfield (1983) finds that with very few exceptions, the scientific output of SPC countries has a lower

impact than the output of developed countries. Even India and Brazil, which are prominent producers of mainstream scientific publications, have very low impact in proportion to the volume of their scientific output (Arunachalam, 1987; Spagnolo, 1990). Arunachalam and Markanday(1981) reported that middle-level countries (Australia, Canada, India, and Israel) also contribute to international literature to a considerably lesser extent than their size would warrant. Arunachalam and Garg(1986) observed that even the mainstream scientific production of southeast Asian countries tends to be published in low-impact journals in the west. Similar results were found in a study of Philippine science conducted by Diluvio(1989), who found that much of "Philippine science" is contributed to by the international agencies and that results are published in journals of lower impact. She concludes that the Philippine make a relatively small contribution to world science.

Negative balance in citation is considered to be a significant characteristic of peripheral journals. That is, scientists in SPC's usually are cited less than they cite others (Arunachalam & Markanday, 1981). Several studies about the citation pattern of SPC scientists found that there is a relatively high proportion of citation by SPC scientists to advanced country literature (Lancaster, et al, 1990; Alabi, 1989; Velho, 1986), while the citation record of science performed in SPC's is poor (Arunachalam & Garg, 1985). Velho (1986) indicated that citation

patterns of scientists in SPCs are significantly influenced by factors "external" to the scientific realm, and SPC scientists' referencing practices reflect patterns of local access to information as well as local institutional factors and rivalries. In addition, she claimed that advanced country scientists do not to research work carried out in SPC because they do not highly esteem it.

It is fairly well established that SPC science relies on relatively older literature, which is already almost totally "consumed." Dependence on rather old literature is a clear indication that these journals do not publish papers of highly current significance, which in turn will partially explain why they are not quoted often in international journals and why they do not get attention from other countries. Another important consequence of doing science with relatively older information is exclusion from those international communication networks in which rapidly obsolescing information is exchanged and published. In several studies (Moravcsik, et al., 1976; Arunachalam & Markanday, 1981; Christovao, 1985; and Davis & Eisemon, 1989), the citation of a much greater proportion of older references in SPC journals than in international journals was noted.

Christovao's research(1985) suggested that SPC's present a dual pattern in the aging of scientific literature:

"developed and underdeveloped countries age the literature of 'international' areas of science in a similar pattern:underdeveloped countries

age the literature reflecting 'local' problems slower than the developed countries age the same literature."

That is, SPC communication uses scientific literature very differently, depending on whether the problem is defined with reference to "international science" or to "local science". This interpretation makes no judgments about the quality of local science. Thus, the aging phenomenon based on local science must be studied relative to the applied character of this science and to the institutional context in which it is produced.

The scientific performance of a given country is meaningful only when assessed comparatively. For example, current output can be measured against the results obtained by other countries. The comparison, however, faces certain technical and conceptual problems: how to do the comparison and what the underlying assumptions are (Spagnolo, 1990). In particular, problems emerge when the research of peripheral countries and of advanced countries is compared. The databases produced in advanced countries, which have usually been used for measuring scientific performance among countries, often seem to be inadequate because of their low coverage of SPC journals. It has been demonstrated by many studies that these databases often do not capture more than a small fraction of SPC scientific output, even though an important segment of research in some specialties (e.g., tropical soils, tropical

diseases) is produced in SPC's (Basuki, 1984; Cagnin, 1985; Russel et al., 1987). Therefore, Velho(1986) noted that when a citation database such as SCI is used to access the national scientific effort of peripheral countries, it is able to grasp only the contributions of these countries to internationally mainstream research, not their national impact or their significance to local research.

To summarize, in results of bibliometric study, SPC science is regularly represented as insignificant with respect to that of the international scientific community, as investigating relatively insignificant local problems, as qualitatively different, and as having been produced by scientists who suffer from incompetence or isolation. And in the SPC scientific communities themselves, there is said to be: 1) a handful of scientists oriented toward mainstream research, who publish abroad and work at elite scientific institutions; and 2) a mass of scientists isolated from the international scientific system, who publish in local journals with little visibility, if they publish at all.

## 2.2 Korea in Science

Braun et al.(1987-1988) provided facts and figures on publication output and relative citation of 107 countries during the period 1978-1980 and 100 of countries during 1981-1985. All countries which produced at least 50 first authored papers in the SCI were included in the study. Taking



the 1978-80 data on all science fields combined, the total Korean publication output ranked number 51, while in the 1981-1985 data it ranked number 42. The total Korean publication output and the relative citation impact in chemistry, based on the 1978-1980 data, ranked number 48 and 36 respectively, while in the mathematics field, the ranks are 51 and 37, respectively. For the 1981-85 data, the total publication output and relative citation impact ranked number 35 and 39 respectively, in chemistry and ranked number 44 and 41 in mathematics.

Davis and Eisemon (1989) described the characteristics of four peripheral Asian scientific communities (Malaysia, Singapore, Taiwan and Korea) in regard to aging phenomenon, citedness, parochialism, language use, etc. According to their study, the Korean profile in mainstream science is dominated by chemistry, physics, engineering, and medicine. Between 1980 and 1985, Korea developed mainstream capability in two other fields: material science and metallurgy. In general, Korean scientific publications show most of the characteristics of peripheral scientific communities. However, Korea is the only country of the four studied to publish in its own language. The majority of Korean scientists published more frequently in the local language, Korean, than in English. Therefore, the authors conclude that "efforts to develop local language journals conclude have enjoyed a measure of success as forums for the

work of some of the country's most active scientists and as expressions of national scientific identity."

### III. METHOD

#### 3.1 Introduction

The present study was designed to analyze the citation pattern by worldwide science literature to research papers written/published in one of the scientifically peripheral countries, Korea, and to Korean scientist who publishes in Korea or abroad. For the study, the Science Citation Index (SCI) and seven Korean journals were selected. The SCI provided a collection of titles of journal articles authored by Korean mathematicians and published in non-Korean journals, and it also provided citation data toward Korean journal articles and Korean scientists.

Seven Korean journals covering general topics in mathematics and chemistry were chosen from which to identify scientific research papers by Korean authors published in the years 1985-1986 and to identify Korean scientists who published their research papers in 1985. Chemistry represents mainstream science in Korea, whereas mathematics does not. In the mathematical field, three nationally leading journals published by the Korean Mathematical Society and the Korean Statistical Society were chosen as follows: 1) Journal of the Korean Mathematical Society; 2)

Bulletin of the Korean Mathematical Society; 3) Journal of the Korean Statistical Society. They are all written in English except one article.

The three chemical journals not covered by SCI were selected from those that are published by the Korean Chemical Society and covered by Chemical Abstracts. They are: 1) Journal of the Korean Chemical Society; 2) Journal of the Korean Institute of Chemical Engineers; and 3) Korean Journal of Chemical Engineering. Finally, the Korean chemical journal covered by SCI, Bulletin of the Korean Chemical Society, was added to the source journals. Among the four chemical journals selected, only one journal, Journal of the Korean Institute of Chemical Engineers, is written in Korean; others in English.

From those seven journals and SCI, the following sample groups were collected: 1) 89 mathematical articles written/published in Korea; 2) 31 research articles authored by Koreans and published in non-Korean mathematical journals; 3) 186 research articles published in Bulletin of the Korean Chemical Society; 4) 321 research articles published in three Korean chemical journals not covered by SCI; and, finally, 5) 189 Korean authors in mathematics and chemistry. The study selected all research articles and Korean Scientists who have a Korean address and a typical Korean name. Using SCI, citation data were gathered from each sample group from its five-year period after publication.

In order to address the five research questions presented in Chapter I, each citation data set was tested by using three hypotheses, and was analyzed in terms of two aspects: 1) who cites these articles/scientists, with special note of self-citation and 2) how quickly these articles/scientists get cited (the immediacy criterion). The following three hypotheses were tested statistically:

1. A science paper written/published in Korea has the same chance of being cited by worldwide science literature as does any other science paper.

2. A science paper written/published in Korea and covered by SCI has the same chance of being cited by worldwide science literature as does a paper not covered by SCI.

3. Korean scientists who publish their science papers in Korean journals have the same chance of being cited by worldwide science literature as those who publish their papers in worldwide journals.

The SAS/PC Program package was used for statistical computations.

### 3.2 Testing the First Hypothesis

In order to test the first hypothesis, research articles by Korean scientists published in the selected three mathematical journals in 1985 and 1986 were collected. A total of 133 articles appeared in these three journals during two years, but only 89 articles (66.9%) of these were

selected. Items excluded were articles written by non-Korean scientists (24 items, or 18.1%) and articles under the headings, "Abstracts of Doctoral Dissertation" (20 items or 15%).

Next, research articles by Korean mathematicians published in non-Korean journals were collected by using SCI. Authors affiliated with a Korean institution were considered to be "Korean scientists." Scientists appearing in SCI under the country heading "South Korea" in the geographic section of the Corporate Index for the years 1984-1986 were identified by affiliations. Almost scientists have a typical Korean name. Only papers by Korean scientists published in journals that appear under the subject categories of "mathematics," "applied mathematics," "statistics," and "probability," which are classified by SCI, were included in the second sample group. In this manner, 31 research articles were identified.

The number of citations which these two sample groups received for the five-year period after publication was counted and compared. That is, the number of citations and 31 research papers published in worldwide mathematical journals were tested statistically, to prove or disprove the first hypothesis. For this purpose, the General Linear Model (GLM) for an unbalanced ANOVA was used because it is used in most unbalanced situations, where there are an unequal number of observations.

### 3.3 Testing the Second Hypothesis

The second hypothesis tests the visibility of peripheral journals through SCI. For this, the Bulletin of the Korean Chemical Society, the only Korean journal covered by SCI, was selected. Among a total of 210 journal articles published in 1985 and 1986, 196 research articles (88.6%) written by Korean scientists were selected. Besides, three Korean chemical journals not covered by SCI were chosen: Journal of the Korean Chemical Society; Journal of the Korean Institute of Chemical Engineers; and Korean Journal of Chemical Engineering. 321 research articles by Korean scientists published in these three journals in 1985 and 1986 were collected.

For the five-year period after publication, a total number of citations received by 196 research articles covered by SCI and 321 research articles not covered by SCI, respectively were counted. The number of the citations from two different sample groups were compared statistically, using the General Linear Model (GLM) for an unbalanced ANOVA, in order to test the validity of the second hypothesis.

### 3.4 Testing the Third Hypothesis

The author selected Korean scientists who published their research papers in the three Korean mathematical and three Korean chemical journals in 1985. A total of 323 first authors appeared in these six journals in 1985, but only 189 (81.5%) were unique individuals who were included in the final analysis. In all,

then, 189 Korean authors were used to investigate the effect of place of publication on rate of citation. Using journal directories, this author determined the place of publication of a journal in which a Korean author published. The SCI was consulted for the five-year period 1985-1989 to determine how many citations each author received.

The third hypothesis tests whether a Korean scientist published in a worldwide journal has a better chance of being cited by worldwide science literature than if he/she published in a local journal. The cited journals were divided into two groups: Korean and non-Korean. The number of citations received by these two groups was tested statistically, using One-way ANOVA. This allowed a comparison to be made of the citation rate for Korean authors publishing in Korean journal and Korean authors publishing outside of Korea. In addition, the citation rate for Korean authors publishing in each outside country (i.e. the U.S.A., the U.K., the Netherlands, Japan, Denmark, Switzerland, and Canada), using One-way ANOVA. For example, the number of citation received by papers in Korean journals was compared with the number of citation received by papers in US journals, using One-way ANOVA. The same procedure was repeated for the number of publications of each of the seven countries in which Korean authors were found to have published.

## IV. DISCUSSION OF RESULT

A detailed account of the methods and procedures for this investigation was developed and presented in the preceding chapter. The sources and process for collection of data were also identified. In this chapter the data actually generated by the source journals in mathematics and chemistry will be presented, analyzed, and interpreted in an effort to test the three hypotheses and to examine two characteristics concerning self-citation and immediacy.

### 4.1 The Citedness of Korean Papers: The First Hypothesis

A science paper written/published in Korea has the same chance of being cited by worldwide science literature as does any other science paper.

Data on citedness of 120 Korean mathematics articles are provided on Table 1. Eighty-nine mathematics articles written/published in Korea have in total been cited only twice during the five-year period after publication. That is, only two papers are cited once each by the worldwide science literature. On the other hand, of 31 articles by Korean scientists published in worldwide mathematical journals during three years, 10 articles have been cited a total of 21 times for the five-year period after publication.

The statistical differences between these two groups were tested by using the General Linear Model for an unbalanced ANOVA. The null

〈Table 1〉 CITEDNESS: Mathematical Papers in Korean Journals (MPKJ)  
VS Mathematical Papers in Non-Korean Journals (MPN-KJ)

Sample Group	# of math papers	# of cited papers	# of citations	citation/paper
MPKJ	89	2 ( 2.2%)	2	0.02
MPN-KJ	31	10 (32.3%)	21	0.68

hypothesis, which there will be no significant difference in the level of citedness between mathematical papers written/published in Korea and those published in worldwide journals, can be rejected at the  $p = .001$  level. (See Table 2)

It is found that the mathematical papers by Korean scientists published in worldwide journals have a better citation record than to Korean mathematical papers, but the citation record in articles by foreign scientists to mathematical papers performed by Korean scientists is, in general, poor. Table 3 shows that nearly half of the citations (47.6%) to the 31 articles published in worldwide journals are self-citations. Only 28.6% of the citations come from foreign

scientists. Therefore, it can be concluded that science papers by Korean scientists published in worldwide journals have a significantly better chance of being cited in worldwide science literature than those written/published in Korea. However, foreign scientists make little use of work emanating from Korean scientists whether they were published in Korea or abroad.

In addition, Table 4 shows how quickly Korean mathematical papers get cited in worldwide science literature. Half of cited mathematical papers in worldwide journals won their first citation within one year of their appearance in print, while two cited papers written/published in Korea were cited once by

〈Table 2〉 Statistical Comparison: MPKJ VS MPN-KJ

Sample Groups	# of papers	# of citation	AVG	STD	DF	SS	F	Pr
MPKJ	89	2	.0225	.1482	1	9.8624	22.94	.0001
MPN-KJ	31	21	.7664	1.2543				

〈Table 3〉 Who Quotes Korean Mathematical Papers?: MPKJ VS MPN-KJ

Sample	# of citations	Self-Citation # (%)	Korean Authors # (%)	Foreign Authors # (%)
MPKJ	2	0 (0)	0 (0)	2 (100)
MPN-KJ	21	10 (47.6)	15 (71.4)	6 (28.6)

〈Table 4〉 How Quickly Are Korean Mathematical Papers Cited?: MPKJ VS MPN-KJ

Type of Data	MPKJ	MPN-KJ
# of papers cited for the first time in the year of publication	0	1
After 1 year of publication	2	4
After 2 years of publication	0	2
After 3 years of publication	0	3
After 4 years of publication	0	0
# of papers cited	2	10

two foreign scientists after one year of publication.

#### 4.2 The Citedness of Korean Papers Covered by

##### SCI: The second Hypothesis

A science paper written/published in Korea and covered by SCI has the same chance of being cited by worldwide science literature as does a paper not covered by SCI.

The second hypothesis tests whether a paper (or a journal) becomes more "visible" upon its appearance in SCI. The number of citations to Korean chemical papers covered by SCI and of those not covered by SCI were counted,

respectively. (See Table 5) For the five-year period after publication, the 186 papers covered by SCI have been cited 230 times, an average 1.2 citations per paper, whereas the 321 papers not covered by SCI have in all been cited 87 times, an average 0.3 citations per paper. 263 of the 321 papers not covered by SCI (more than 80%) were not cited even once.

The General Linear Model for an unbalanced ANOVA test was used to test the null hypothesis that there is not an association between the appearance in SCI and the citation. The null hypothesis of independence is rejected at the 0.001 significance level. (See Table 6) We can, therefore, observe that there is a statistically significant relationship between the appearance

〈Table 5〉 CITEDNESS: Korean Chemical Papers Covered by SCI (KCPS)  
VS Korean Chemical Papers not Covered by SCI (KCPN-S)

Sample Group	# of chem papers	# of cited papers	# of citations	Citation/paper
KCPS	186	101 (54.3%)	230	1.2
KCPN-S	321	58 (18.7%)	87	0.3

〈Table 6〉 Statistical Comparison: KCPS VS KCPN-S

Sample Groups	# of papers	# of citation	AVG	STD	DF	SS	F	Pr
KCPS	186	230	1.247	1.776	1	112.2438	77.22	.0001
KCPN-S	321	87	.271	.678				

in SCI and the citation. In other words, this result shows convincingly that more citations are recorded of articles from a scientific journal which is selected for regular processing in SCI.

Table 7 shows who cites Korean chemical papers. Very surprisingly, it is found that the proportion of citation in papers by foreign scientist to SCI-covered Korean papers is very low (19.1%), while that of citations between foreign scientists and Korean papers not covered by SCI is relatively high (53.3%). Furthermore, the number of citations of those covered by SCI by foreign scientists is somewhat smaller than of those not covered by SCI. That is, it is found that foreign scientists make little use of Korean scientific works covered by SCI, but the citation record of Korean papers covered by SCI in worldwide science literature is comparatively "good" because Korean authors publishing abroad frequently cite those papers. Therefore, it seems that the visibility through SCI does affect

those Korean who cites the scientific work of others, but does not affect the number of citations of Korean works by foreign scientists.

The data on the Table 8 indicate that the Korean chemical papers covered by SCI are cited more quickly. Fifty-seven cited papers (56.4%) covered by SCI won their first citation within one year of their appearance in print, while only 15 cited papers (25.9%) not covered by SCI won their first citation during the same period. It can, therefore, be inferred that the visibility through SCI does determine immediacy of citation rather than the citation pattern of worldwide scientists to peripheral journals.

#### 4.3 The Citedness of Korean Scientists: The Third Hypothesis

Korean scientists who publish their science papers in Korean journals have the same chance of being cited by worldwide science literature as those who

〈Table 7〉 Who Quotes Korean Chemical Papers?: KCPS VS KCPN-S

Sample Group	# of citations	Self-Citation # (%)	Korean Authors # (%)	Foreign Authors # (%)
KCPS	230	129 (56.1)	196 (80.9)	44 (19.1)
KCPN-S	87	23 (26.4)	38 (43.7)	49 (56.3)

〈Table 8〉 How Quickly Are Korean Chemical Papers Cited?: KCPS VS KCPN-S

Type of Data	KCPS # (%)	KCPN-S # (%)
# of papers cited for the first time in the year of publication	13 (12.9)	3 ( 5.2)
After 1 year of publication	44 (43.5)	12 (20.7)
After 2 years of publication	24 (23.8)	10 (17.2)
After 3 years of publication	14 (13.9)	18 (31.0)
After 4 years of publication	6 ( 5.9)	15 (25.9)
# of papers cited	101 (100)	58 (100)

publish their papers in worldwide journals.

In total, 189 Korean scientists received 6,483 citations through 2,560 papers cited in worldwide science literature for the five-year period 1985-1989. Of the 2,560 cited papers, 362 papers (14.1%) published in Korean journals have been cited 527 times, an average of 1.46 citations per paper, while 2,198 papers (85.9%) in non-Korean journals have been cited 5,956 times, an average of 2.71 citations per paper, during the five-year period. (See Table 9)

Table 10 gives the breakdown of citations to Korean papers by the publication place of the cited journals (i.e., country). Not surprisingly, the papers published in US journals received the

largest number of citations (68.3%), followed by those from Korean journals (8.1%). UK journals came in third (6.2%) and the Netherlands journals (5%) fourth. Moreover, it is found that 77 cited Korean authors who publish in Korean journals received 527 citations by worldwide science literature, an average of 1.46 citations per paper. This ratio is very low, compared to the other ratios from worldwide journals, which are similar to each other. Therefore, this indicates that a paper published in a Korean journal receives a small number of citations (usually one or two), and/or there is a very small number of highly cited papers.

The number of citations received by Koreans journals and Non-Korean journals is compared in

〈Table 9〉 Citedness: Korean Journals vs Non-Korean Journals

	# of cited papers	# of citations	citations/paper
Korean Journal	362	527	1.46
Non-Kor Journal	2198	5956	2.71
Total	2560	6483	



〈Table 10〉 Citedness: KOR, US, UK, NE, JN, DK, SZ, and CN

Country	# of cited authors	# of cited papers	# of citations	citation/paper
KOR	77	362 (14.1)	527 ( 8.1)	1.46
US	97	1547 (60.4)	4426 (68.3)	2.86
UK	38	148 ( 5.8)	399 ( 6.2)	2.70
NE	35	140 ( 5.5)	327 ( 5.0)	2.34
JN	28	98 ( 3.8)	215 ( 3.3)	2.19
DK	11	62 ( 2.4)	158 ( 2.4)	2.55
SZ	15	43 ( 1.7)	105 ( 1.6)	2.44
CN	10	41 ( 1.6)	103 ( 1.6)	2.51
others	33	59 ( 2.3)	115 ( 1.8)	1.95
U.I*	40	60 ( 2.3)	108 ( 1.7)	1.5
Total		2560 (100)	6483 (100)	

\* Unidentified items

order to test the null hypothesis of the third hypothesis. The null hypothesis states that there is no relationship between the place of publication and the citation. The results of the One-way ANOVA as seen in Table 11 show that the null hypothesis can be rejected at the  $p = .001$  level. Thus, when Korean scientists publish in worldwide scientific journals, they receive more citations by worldwide science literature.

In addition, the citation rate for Korean authors publishing in each outside country (i.e.,

the U. S. A., the U. K., the Netherlands, Japan, Denmark, Switzerland, and Canada) was compared respectively with the citation rate for Korean authors publishing in Korean journals using One-way ANOVA. (See Table 12) From the results of these comparisons, it is found that Korean scientists receive a significantly large number of citations when they publish in US journals. But, when Korean scientists publish in journals in Japan, Denmark, Switzerland, and Canada, they have less chance of being cited than when they publish in local journals.

〈Table 11〉 One-Way ANOVA: KOR VS NON-KOR

	# of citations	AVG	STD	F	Pr.	Sign
KOR	327	2.7884	9.5068	32.77	.0001	S ( $p = .001$ )
NON-KOR	5956	30.4868	65.6599			

〈Table 12〉 One-Way ANOVA: KOR VS US, UK, NE, JN, DK, SZ, and CN

	# of citations	AVG	STD	F	Pr	Signif
KOR	327	2.7884	9.5068			
US	4426	23.4180	54.4985	26.14	.0001	S (P= .001)
UK	399	2.1111	8.1288	.55	.4583	NS
NE	327	1.7302	6.9978	1.51	.2198	NS
JN	215	1.1376	4.0016	4.42	.0288	S (P= .05 )
DK	158	.8360	6.2547	5.53	.0192	S (P= .05 )
SZ	105	.556	2.8402	9.52	.0022	S (P= .005)
CN	103	.5450	4.8680	8.29	.0042	S (P= .005)

〈Table 13〉 How quickly are Korean scientists cited?

	KOR # (%)	US # (%)	UK # (%)	NE # (%)
in the year of publication	22 ( 4.2)	164 ( 3.7)	17 ( 4.3)	13 ( 4.0)
after 1 yr	79 (15.0)	606 (13.7)	71 (17.8)	43 (13.1)
" 2 yrs	85 (16.1)	634 (14.3)	73 (18.3)	26 ( 8.0)
" 3 yrs	76 (14.1)	552 (12.5)	64 (16.0)	50 (15.3)
" 4 yrs	66 (12.5)	366 ( 8.3)	49 (12.3)	21 ( 6.4)
" 5 yrs	52 ( 9.9)	331 ( 7.5)	19 ( 4.8)	23 ( 7.0)
[total]	[380 (72.1)]	[2653 (59.9)]	[293 (73.4)]	[176 (53.8)]
within 5-10 yrs	99 (18.8)	816 (18.4)	62 (15.5)	51 (15.6)
" 11-15 yrs	33 ( 6.3)	625 (14.1)	18 ( 4.5)	69 (21.1)
" 16-20 yrs	9 ( 1.7)	229 ( 5.2)	14 ( 3.5)	27 ( 8.3)
" 21-25 yrs	5 ( 0.9)	82 ( 1.9)	6 ( 1.5)	4 ( 1.2)
" 26-30 yrs	1 ( 0.2)	6 ( 0.1)	1 ( 0.3)	-
" 31-40 yrs	-	11 ( 0.2)	5 ( 1.2)	-
after 41 yrs	-	4 ( 0.1)	-	-
Total	527	4426	399	327

It is of interest to learn how quickly Korean authors get cited in worldwide science literature. In general, Korean scientists receive the largest number of citations in worldwide science literature in the second year after publication, and they receive more than 50 percent of their citations within 5 years after publication, whether they publish in Korean journals or in worldwide journals. In fact, Korean scientists who publish in Korean journals and UK journals are cited more quickly, than are those who publish in US journals. However, the difference is not significant. In addition, it is found that the Korean scientists who published in US journals more than forty years ago, are still cited in worldwide science literature.

## V. SUMMARY AND CONCLUSIONS

This study was undertaken in order to gain some insight into the citedness of a scientific paper published in a scientifically peripheral country (SPC), or of an SPC scientist. In particular, it was designed to investigate the citation record by worldwide science literature of scientific literature emanating from Korea.

Considering the originally stated hypotheses, the findings of this study are as follows:

1. The first hypothesis stated that a science paper written/published in Korea has the same chance of being cited by worldwide science literature as does any other science paper. The

statistical test shows that mathematical papers by Korean scientists published in worldwide journals, tend to have a better chance of being cited by worldwide science literature, which proves that the first hypothesis is not supported. However, in the data from papers in worldwide journals, a high proportion of self-citation and small proportion of citations from foreign scientists were found. Therefore, it can be inferred that foreign scientists make little use of work emanating from Korean scientist whether they publish in Korea or abroad.

2. The second hypothesis tested whether a paper becomes more "visible" upon its appearance in SCI. It stated that a science paper written/published in Korea and covered by SCI has the same chance of being cited by worldwide science literature as does a paper not covered by SCI. The statistical test shows that there is a relationship between the appearance in SCI and the citation. In other words, the scientific papers covered by SCI tend to have a better chance of being cited by worldwide science literature. One can conclude that the second hypothesis is not supported. When considering the citation record of foreign scientists, the visibility through SCI does influence the immediacy of citation, rather than the citation pattern of foreign scientists.

3. The third hypothesis stated that Korean scientists who publish their science papers in Korean journals have the same chance of being cited by worldwide science literature as those

who publish their papers in worldwide journals. The test shows that the third hypothesis is not supported: that is, Korean scientists who publish in worldwide scientific journals tend to have a better chance of being cited by worldwide science literature. In addition, it is found that Korean scientists receive the largest number of citations from worldwide science literature in the second year after publication, and that they also receive more than fifty percent of their citations within five years after publication, whether they publish in local journals or not.

Using Velho's data, which are the citation records to Brazilian agricultural research, Moravcsik generalized scientific literature performed by an SPC as follows:

"...a given paper written in a developing country has as good a chance to be cited by the worldwide scientific literature as any other scientific paper... articles from the Third World are not discriminated against. (1987, p. 57)"

This surprising conclusion raised several research questions concerning the visibility of SPC journals or SPC scientists. As result of investigating the citedness of SPC science (in particular, Korean science), it was found that Korean scientific literature has poor citability. That is, the citation record of the scientific papers written/published in Korea is very weak. Even though Korean scientists publish in worldwide journals, or even if Korean papers

have the visibility through SCI, it is found that foreign scientists make little use of scientific research emanating from Korea.

In general, there is a negligible proportion of citations in papers by foreign scientists to scientific literature from Korea. Therefore, a crude interpretation might conclude that peripheral country publications would appear to have had little impact or influence in the scientific activity of advanced country researchers, and that Korean scientists make a relatively small contribution to world science. However, it is also true that the peripheral journal has its own scientific value, of a "small" journal, that can "keep it alive" within the world's science.

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