Measuring the citation impact of research journals in clinical neurology: a structural equation model analysis

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Abstract
This study develops and tests an integrated conceptual model of journal evaluation from varying perspectives of citation analysis. The main objective is to obtain a more complete understanding of the external factors affecting journal citation impact. Structural equation modeling (SEM) with partial least squares (PLS) is used to test the conceptual models with empirical data from journals in clinical neurology. Inter-relationships among journal citation impact and four external factors (journal characteristics, journal accessibility, journal visibility and journal internationality) have been successfully explored, and the conceptual model of journal evaluation has been confirmed.

1.   Introduction

As an important scholarly communication media, journals play a primary role in disseminating the scholarly information within and between disciplines. Not surprisingly, the value of journals in an academic discipline is significant to both individual academics and to the scholarly community. Traditionally, studies evaluating the overall quality of journals have focused on peer assessment through subjective opinion surveys. However, based on the normative perspective of citation, which views citing as a merit-granting process, it is plausible to assume that the information value of a given publication is reflected by the frequency of citations obtained from other publications. Therefore, citation counts can be used as indicators or measurements of the level of quality, importance, impact, influence or performance of individual publications or aggregations of publications, such as journals (Wilson, 1999). In the past decades, citation analysis has been extensively utilized as a practical alternative to subjective judgmental approaches. Journal citation indicators from the Institute of Scientific Information (ISI) have become popular measures in assessing journal impact, in particular, the journal impact factor and the number of total citations.

Nevertheless, constructivists, who disagree that science is an institution wholly governed by a set of internally sanctioned norms, are dubious of the evaluative role of citation analysis. They question the validity of the normative aspect of citation analysis in that citations are mainly rhetorical devices rather than devices to acknowledge intellectual merits. Moreover, they indicated that the citation process is complex and it is affected by certain external factors (Cronin, 1984; Gilbert, 1977).

Meanwhile, during the debate between normative perspective and constructivist perspective of citing, some researchers have pointed out that there were certain connections between the two perspectives and their dynamic linkage would lead to a satisfactory theory of citation (Liu, 1997; Leydesdorff, 1987). For example, Garfield (1979), the founder of the *Science Citation Index* and the journal impact factor, indicated that scientific merit was not always the sole reason an author would cite a paper published in a particular journal. Garfield further stated that an author's citation behavior might be influenced to varying degrees by the reputation of the cited author or the visibility, prestige, and accessibility of the cited journal. Likewise, Cronin (1984) also suggested that social and psychological factors as well as other external factors, such as the target audience or the character and status of cited journal, affect the citing process.

The discussions and arguments about the perspectives of citation analysis are ongoing and various citation measures continue being employed to assess journal impact, despite the lack of a universally accepted theory of citing. In order to apply citation analysis to evaluate journals more objectively and comprehensively, we need a better understanding of how external factors

influence journal citation impact. To date, little effort has been made to explore the complex interrelationships among the various external factors with respect to the journal citation impact. Thus, how and to what extent the external factors influence the journal citation impact in the context of journal evaluation becomes a crucial issue.

This study is motivated (in part) by the discussions in the development of citation theories. Bearing in mind the different perspectives of citation analysis, this research develops and tests an integrated conceptual model of journal evaluation. The main objective of this study is to obtain a more complete understanding of the factors affecting journal citation impact. Although similar issues have been discussed in previous literatures, the proposed model is novel in that it (1) identifies the external factors that affect journal citation impact; (2) identifies the empirical indicators of the external factors and journal citation impact; (3) addresses the complex interrelationships between these external factors and journal citation impact in one case study; and (4) studies the extent to which the journal citation impact is influenced by the external factors.

2.   Methodology

2.1   Research Questions
This study identifies five constructs: journal characteristics, journal accessibility, journal visibility, journal internationality, and journal citation impact; and addresses the following interrelated research question: What is the strength of the relationship between journal citation impact and, in turn, each of the five constructs above?

2.2   Models Developed
This study uses structural equation modeling (SEM) with partial least squares (PLS) – a relatively new approach for testing multivariate models with empirical data. SEM incorporates both observed and latent variables – usually these variables can be separated into a structural model and several measurement models. The measurement models address the reliability and validity of the indicators in measuring latent variables or hypothetical constructs, while the structural model specifies the direct and indirect relations among the latent variables and describes the extent of explained and unexplained variance in the model.

Instead of using co-variance based SEM techniques, PLS was used as the primary strategy for examining the relative effects of external factors on the journal citation impact, as it is suitable for causal-predictive analysis in situations of high complexity but low theoretical information. In addition, PLS makes no prior distributional assumptions and is applicable to small sample size (Sambamurthy & Chin, 1994).

2.21   Structural Model
A structural model is regression-based. It consists of the unobservable constructs and the theoretical relationships among them (Igbaria et al., 1995). In this research, the structural model has been developed on the basis of the theoretical works of citation analysis and previous empirical findings of journal evaluation. Five constructs have been chosen for the structural model and four propositions were developed from the structural model. Figure 1 graphically depicts the propositions to be tested.
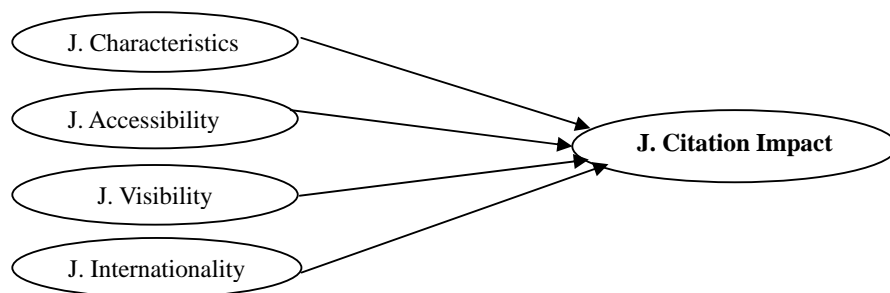

Figure 1. Structural model of journal evaluation

Journal Citation Impact: Impact is defined as a forceful consequence or strong influence. In this study, journal citation impact is used to refer to the influence of the journal as gauged by the uses made of the journals through citations. It is reflected through various journal indicators from ISI, e.g., impact factor, immediacy index, cited/citing rate, number of total citations, and the number of disciplines using or citing the journal.

Journal Characteristics: This construct is partly an "editor-driven" concept, which describes the basic and historical attributes of a particular journal. Journal characteristics include *inter alia*: age, size, frequency, document type, multidisciplinarity, societal affiliation, and average number of references per article.

Journal Accessibility: Journal accessibility specifies the availability of a journal when needed. It is a multidimensional concept encompassing physical and content access of journals. Journal circulation (or subscription), language, and online versions are indicators of accessibility, and thus, mainly a "publisher-controlled" construct.

Journal Visibility: The term "journal visibility" has been used in previous studies with several explanations. However, in this particular study, it describes the extent to which a journal is 'seen' by the academic community. It is gauged by the number of Abstracting and Indexing (A&I) services or databases that choose to include a particular journal. Journal visibility is an external factor generally outside the control of journal editors and editorial boards.

Journal Internationality: Journal internationality refers to the quality of being international or globe in scope. It includes the nationality (or country affiliation) of the authors, the editors and members of the editorial board, and the citing authors who use a particular journal.

2.22 Measurement Models

There are five measurement models developed for the five constructs in the structural model. The measurement model consists of the relationships between the observed variables and the constructs measured. Indicators for each construct are derived from those used in previous studies. When using SEM with PLS, the indicators in the measurement model can be modeled as reflective or formative. Reflective indicators are viewed as affected by the same underlying concept (i.e., the Latent Variable or LV). In contrast, formative indicators are measures that form or cause the creation or change in a LV (Chin, 1998). Journal characteristics, journal accessibility, journal visibility, and journal internationality were expected to be caused by their indicators. Hence, indicators in these constructs were modeled formatively. On the contrary, journal citation impact was expected to affect these indicators. Hence, its indicators were modeled reflectively. The five measurement models are shown with all their indicators in Figures 2 to 6.

Measurement Model of Journal Citation Impact: The indicators of citation impact used in this study are either obtained or calculated from the ISI data. The cited half-life may be regarded as an impact indicator; however, we have not included this in our study as many of the journals no values or are >10.

  Impact factor: The journal impact factor is a measure of the frequency with which the "average article" in a journal has been cited in a particular year. The ISI impact factor for the year 2000 is used.

  Immediacy index: The journal immediacy index is a measure of how quickly the "average article" in a journal is cited and for this study, the 2000 immediacy index is used.

  Total citations: The indicator for total citations refers to the total number of citations to articles in a journal for the year 2000.

  Cited/Citing rate: In previous study, Cited/Citing rate was regarded as a quality index of

scientific journals (Price, 1981; Pinski & Narin, 1976) or the input/output ratio reflecting the status of the journal in a given network (Kim, 1992). In our study, this indicator is calculated by dividing the total number of citations that a journal received by the total number of references that the same journal has given, both numbers for the year 2000.

Citing disciplines: Citing discipline refers to the extent of the inter- or multi- disciplinary impact of a journal. It can be traced through the analysis of subject areas where citations are coming from (Wormell, 1998). It is measured by the number of citing disciplines, obtained by using Dialog to search all the citations of each journal in clinical neurology and then ranking the subject category (SC) field.
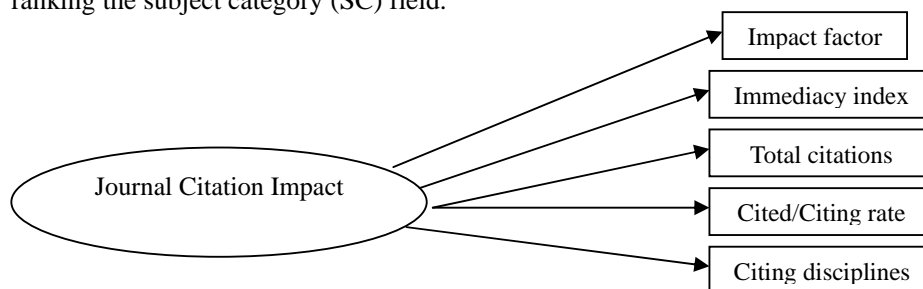
Figure 2. Measurement model of journal citation impact

Measurement Model of Journal Characteristics: Journal characteristics are measured by the journal age, size, publication frequency, document type, multidisciplinarity, number of societal affiliations, and the average number of references per article.

Journal age: Journal age was calculated from the year the journal was first published regardless of how many times the journal has changed its title or altered its scope.

Journal size: Journal size is defined as the total number of articles the journal published in the year 2000. The number can vary widely depending on, for example, the preponderance of particular document types such as 'meeting abstracts'.

Frequency: Frequency of a journal is the number of issues the journal publishes each year. Similar to the journal size, this measurement would influence the overall contributions of a journal to a discipline (Ali et al., 1996).

Document type: In scientific disciplines, a majority of scholarly journals tend to carry only research articles and book reviews. Some journals themselves are review journals. It is necessary to distinguish the type of documents the journal publishes. The document types may include research papers, reviews, editorials, brief communication, meeting abstracts, and letters (irrespective of the length).

Multidisciplinarity: Each journal in the ISI database is assigned at least one subject category, indicating a specific area of knowledge. Journals may be included in more than one subject category; therefore, the extent or number of subject areas a journal covers can be an indicator of the journal's multidisciplinarity.

Affiliation: The number of affiliations a journal has with academic societies is another indicator of a journal's characteristics.

References/Article: The ratio of journal references/article is calculated by dividing the total number of references at the end of each article published in 2000 by the total number of articles in the same year.
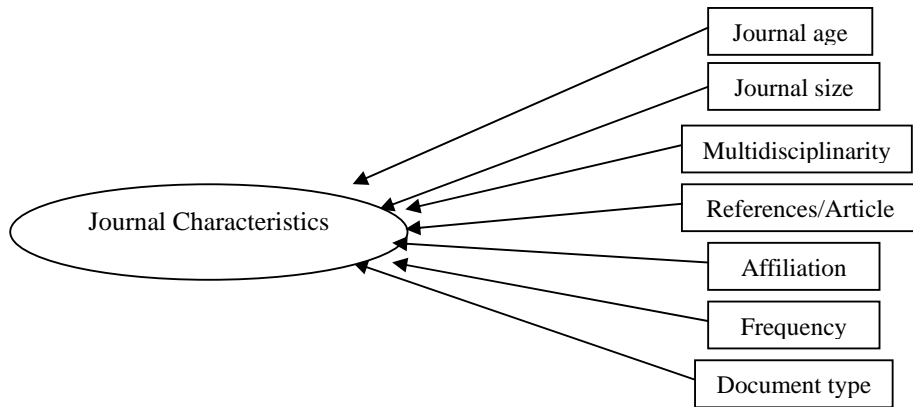
Figure 3. Measurement model of journal characteristics

Measurement Model of Journal Accessibility: The indicators of journal accessibility include: circulation, electronic availability, and publication language of the journal.

Circulation: Although circulation size may over-represent a popular generalist journal and under-represent a scholarly specialist journal, it can still be used as a measure of a journal's accessibility in a discipline. Thus, in this study circulation size from the *Ulrich's* database is regarded as an indicator of the journal accessibility.

Electronic version: A notable trend of well-established print publishers such as Elsevier, Academic Press, and Springer-Verlag is the simultaneous publication of journals in electronic as well as print. As electronic versions are generally more convenient for authors to access, print journals having online counterparts are more accessible. If a journal has an online counterpart, it will be assigned a value of 1; otherwise the value will be 0. However, when we found that all the journals included in this study had online versions, this measure was deleted.

Language: More than 95% of journals in the ISI databases are in English and the role of English as the major language of modern science is striking (Van Leeuwen, et al., 2001). Thus, the language of publication becomes an important indicator. It is a 'dummy' variable.
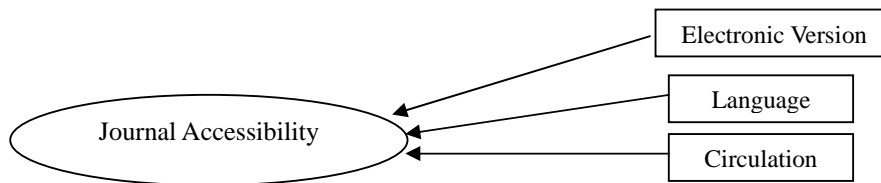

Figure 4. Measurement model of journal accessibility

Measurement Model of Journal Visibility:

A&I services: Journal visibility is indicated by the number of Abstracting & Indexing (A&I) services or databases covering the journal. This measure is defined as the total number of A&I services or databases indexing a journal. The more A&I services indexing a journal, the wider the potential audience of readers (Ali et al., 1996).
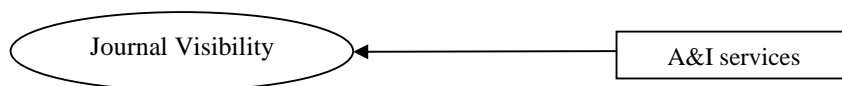

Figure 5. Measurement model of journal visibility

Measurement Model of Journal Internationality: Journal internationality is measured by the

number of country affiliations of researchers, citing authors, and editorial board members. In previous studies, this construct has been discussed from various aspects: the international scope of the readers (Wormell, 1998) and the editorial board (Zsindely et al., 1982); the geographical source of citations (Ren & Rousseau, 2002; Wormell, 1998); and affiliation data of the authors (Gutiérrez & López-Nieva, 2001). In this paper, due to the difficulty of obtaining readership information from the publishers, we regard the actual users' (that is, citing authors') geographic location distribution as a measure to replace the readership internationality.
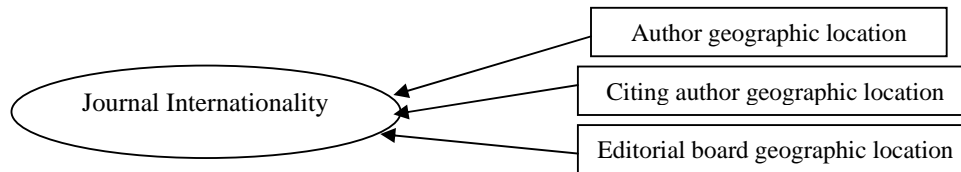

Figure 6. Measurement model of journal internationality

Authorship Geographic Location: Geographical locations (GL) or the country affiliation of all 'source' authors in a particular journal in 2000 can be obtained from SCI; further, the GL field can be ranked to produce a list of countries in decreasing order of productivity. Hence, the internationality of journals can be determined by the number of country affiliations of authors.

Citing Author Geographic Location: As with the country affiliations of the 'source' authors, the GLs of citing authors of documents in each journal in 2000 can be obtained. The method of assigning values to this measure for each journal is the same as one for assigning values to the 'source' authors.

Editorial Board Geographic Location: The number of country affiliations of the editors-in-chief and editorial board members were also determined for each journal in 2000.

2.3 Propositions

(1) Journal characteristics affect journal citation impact: Numerous studies have found that journal characteristics influence different citation indicators. For instance, the frequency and the size of a journal have a positive effect on the value of the journal impact factor (Rousseau & Hooydonk, 1996). Journal age has been regarded as the main factor for the number of total citations (Cooper et al, 1993; Dombrowski, 1988). It is generally assumed that a journal would have an established reputation if it has been published for a substantial number of years (Ali et al., 1996). Moreover, the document type of articles in a journal often influences the journal citation impact. For example, review journals will generally attract more citations due to its special publication type. Additionally, the coverage or scope of a journal is also regarded as a measure of citation impact (Dombrowski, 1988). The argument is that the more disciplines the journal content covers, the more people would use it and thus the more citations the journal would attract. Further, the average number of references per article is related to the number of citations received by psychology articles (Lindsey, 1978). Smart and Elton (1981) also pointed out that the citation frequency could be explained by journal structural characteristics, such as journal size, references per article, and disciplinary focus. In short, as indicated by Cozzens (1989), there is a need to analyze journal characteristics in terms of citation inflators or deflators. Thus, journal characteristics are proposed to affect the journal citation impact.

(2) Journal accessibility affects journal citation impact: Journal accessibility is a multidimensional concept encompassing both physical and content access to the journals. It is measured by circulation, language of publication, and availability in electronic versions (McCracken & Coffey, 1996; Bioscience, 1973). One reason for not citing relevant works was the inaccessibility of the journal (Dubios & Reeb, 2000; Gorman, 2000; Van Dalen & Henkens, 1999; Cooper et al., 1993). The unavailability of the journal might be due to physical inaccessibility or

other factors that hinder potential citers from using the work, e.g., language. Further, the language of publication can also affect the number of citations (Dombrowski, 1988) because the *Journal Citation Reports* favor journals published in English. As journal accessibility influences citation behavior, it is proposed in this study that journal accessibility affect journal citation impact.

(3) Journal visibility affects journal citation impact: Previous studies state that coverage by Abstracting and Indexing (A&I) services influence the citation rates of the journal (Cooper et al., 1993). The argument is that the more A&I services indexing the journal, the more opportunity the journal could be cited. Thus, it is proposed that journal visibility would affect the journal citation impact.

(4) Journal internationality affects journal citation impact: Although the issue of journal internationality has been discussed, there are few studies investigating the relationship between the journal internationality and journal citation impact. Theoretically, if a journal has a larger cohort of international 'source' authors and citing authors, the journal would attract more citations and perhaps would be more 'influential'. Thus, it is proposed that journal internationality would affect journal citation impact.

2.4 Data Collection

All the observed variables were collected from the following sources: *Journal Citation Reports*; *Ulrich's International Periodicals Directory*; *Science Citation Index (SCI)*; National Library of Medicine's LOCATORplus; World wide web; and printed versions of journals.

Data analysis is based on 34 journals from the clinical neurology journal subject category in ISI's *Journal Citation Reports* (JCR) for 2000. Only journals with complete data were considered in this study. Moreover, in order to obtain a complete profile for each journal, journals that have changed titles, merged with another journal or split into two or more journals are regarded as the same journal. Different data on journal age from different sources have been resolved by tracing the journal back in time.

3.   Results and Discussion

3.1 Structural Model

PLS-Graph (version 3.00) was used to analyze the data. The multiple R^2 values given for the dependent construct is equivalent to the value derived from the regression, which indicates the fraction of total variance in the dependent construct accounted for by those independent constructs (Mathieson et al., 2001). In our study, the R^2 of the journal citation impact is 0.75, showing that the four external factors explained 75% of the variance of the journal citation impact.

Moreover, the stability of the estimates or the significance of paths was tested via a "jackknifing" resampling procedure, which can provide a general device for "blindfolding" to assess standard errors of the parameter estimates (Sambamurthy & Chin, 1994). Overall, the significance at the 0.05 level of all the four path coefficients provides support for the research propositions. All the path coefficients between the research constructs are expressed in a standardized form to permit comparison of the relative strengths. The results of this study support our propositions that external factors influence the journal citation impact. In particular, journal internationality (path coefficient 0.586) and journal characteristics (0.281) have important influence on the journal citation impact while journal visibility (0.048) has a weak influence on the journal citation impact. However, a somewhat surprising result was that journal accessibility has a slightly negative influence (-0.061) on journal citation impact. This might be due to some missing values in the circulation data. Also, the incomplete data set may lead to this unexpected result, as we could not obtain the full data for most non-English journals. Further study is needed to address this problem.

3.2 Measurement Models

In addition, PLS enables the assessment of measurement components by providing loadings and weights of indicators. Weights are appropriate for interpreting the effects for formative constructs while loadings are more suitable for examination of reflective constructs.

Formative indicators are weighted according to their relative importance in forming the construct. Thus, the weights allow us to determine the extent to which each indicator contributed to the development of the construct. The general approach is to compare the weights of different indicators and see how close the weights are to 1.0 (Sambamurthy & Chin, 1994). Table 1 shows the weights for all formative indicators in the model, thus, showing the reliability of the indicators for all the constructs.

Table 1. Formative constructs, indicators, and weights

Construct	Indicator	Weight
Journal Characteristics	Journal size	0.908
	Journal age	0.127
	Frequency	-0.378
	Document type	0.334
	References/article	0.105
	Number of affiliation	-0.380
	Multidisciplinary	-0.062
Journal Accessibility	Language	0.357
	Circulation	0.911
Journal Internationality	Author internationality	0.007
	Citing author internationality	0.964
	Editorial internationality	-0.148
Journal Visibility	Number of A&I services	1.000

Meanwhile, each reflective construct is viewed as an existing entity. The extent to which each indicator reflects the underlying construct can be determined by examining the loadings. Table 2 shows that all indicators for journal citation impact strongly reflect their respective constructs (above 0.800), and thus confirms our construct design of journal citation impact.

Table 2. Reflective construct, indicators and loadings

Construct	Indicator	Loading
Journal Citation Impact	Impact factor	0.872
	Immediacy index	0.845
	Total citations	0.895
	Cited/Citing ratio	0.920
	Citing disciplines	0.865

It is not surprising that journal characteristics have an influence on journal citation impact. However, the influence is not as strong as we had expected. Among all the indicators of journal characteristics, journal size with a weight of 0.908 certainly contributes most to the formation of the construct. It confirmed the previous study that the size of journals positively affects the journal impact factor (Rousseau & Hooydonk, 1996). However, it is surprising to find that frequency has a negative role in the journal characteristics constructs. Meanwhile, the number of document type with a weight of 0.334 contributes moderately to journal characteristics. Although journal age was considered to have a strong influence on the number of total citations (Cooper et

al., 1993; Dombroski, 1988), the result in our study did not support the findings in previous studies. Moreover, our model shows that the number of organizations with which the journal affiliates and the number of disciplines the journal covers do not support journal characteristics. In future studies, we suggest that the affiliation variable should be measured as a 'dummy' variable instead of the actual number of affiliations.

Although previous studies indicated that the number of A&I services indexing a journal could be an indicator for an increase number of citations (Cooper et al., 1993), journal visibility in our study did not demonstrate a strong influence on journal citation impact. This can be explained in part by the fact most readers/users of journals in clinical neurology are specialists who are quite familiar with journals in their field. Therefore, we think that A&I services may not particularly influence their citing behavior.

Data in Table 1 confirmed that language and circulation are important factors in forming journal accessibility, with weights of 0.357 and 0.991 respectively. However, the negative relationship between journal accessibility and journal citation impact was not consistent with the discussion in prior research that language and physical *inaccessibility* would hinder the users in citing the works (Dubios & Reeb, 2000; Gorman, 2000; Van Dalen & Henkens, 1999; Cooper et al., 1993; Dombrowski, 1988). As mentioned above, one explanation might be the use of missing values in the circulation variable. Further, the number of circulation figures obtained from the *Ulrich 's* database may not completely reflect the actual number of users, particularly in the case of organizational subscription.

As expected, journal internationality had a strong influence on journal citation impact, which confirmed our proposition 4; in particular, citing author internationality contributed greatly (0.964). It confirms the notion of adding citing authors' geographic location in this construct. However, author internationality did not contribute to journal internationality and there was a low correlation between author internationality and journal citation impact. This finding is consistent with a previous study that author internationality and the average impact factor (IF) are not correlated (Gutiérrez & López-Nieva, 2001). Likewise, Zitt and Bassecoulard (1998) also discovered that their internationalization indicators correlated only moderately with journal impact. On the other hand, editorial internationality contributed negatively to journal internationality. This was expected, as we found that the editorial board of a number of 'top' journals (based on IFs or total citations) in clinical neurology are by North Americans and therefore, have only one or two geographical locations, the USA and/or Canada. We also found that journals with editorial board members from a number of different countries do not have high Ifs or total citation counts.

4. Conclusion

In conclusion, inter-relationships among journal citation impact and the four external factors have been successfully explored, and our conceptual model of journal evaluation has been confirmed. However, there are some limitations related to measurement reliability and research validity. It should be emphasized that *"The model works for a single population, using a single system at a single point in time"* (Mathieson, et al. 2001, p208). Additionally, other potential equivalent models are possible. Hence, it is suggested that issues concerning cultural and disciplinary biases need to be considered before generalizing our research findings. We suggest that future research be extended to other disciplines. Further, other potential external factors of journal citation impact should be explored in future research.

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