THE IMPACT OF KNOWLEDGE EXPORTS FROM LIBRARIANSHIP AND INFORMATION SCIENCE: INVESTIGATING CROSS-DISCIPLINARY CITATIONS

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Abstract

Background: Import-export studies use citations to assess the exchange of ideas between disciplines. The literature demonstrates a wide application of import-export methodologies. In order to make import-export studies as effective as possible there is a need to quantify the value of exports. Impact factors provide a means of doing this.

Aims: The study aimed to investigate the influence of librarianship and information science (LIS) exports, and the extent to which import-export studies in LIS can be enhanced by incorporating the measure of journal impact factor (IF).

Methods: A body of high quality LIS literature was identified from submissions to the 2008 Research Assessment Exercise. All citations to these articles were collated using Web of Science Cited Reference Search. Full exports from LIS were defined by looking at the subject categorisations of citing journals. Analyses were carried out on 1061 exports in 444 unique journals. Impact factors were obtained from Journal Citation Reports for each citing journal, and normalised to make them cross-comparable.

Results: Citation patterns and impact factor distributions were significantly affected by the particular foci of the original LIS articles, and by bulk imports from single articles, authors, or departments. Normalised impact factor distributions show that the majority of non-LIS citing journals can be considered above average for their subject categories. This pattern is considerably more pronounced for citations to LIS articles published in non-LIS journals than for citations to fully internal LIS research.

Conclusions: Exported knowledge from LIS is achieving a significant level of influence and impact. High citation counts or NIF values do not always represent consistent export channels, though. Crucially, LIS research is more likely to get cited in high impact journals when it is initially published in a non-LIS journal. Impact factors, once normalised, provide an effective means of quantifying the value of varied LIS exports.

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1 Introduction

1.1 Background context

The ideas and research generated by an academic discipline are crystallised within the published output of that discipline. Within these publications, citations occur when an author acknowledges another's work, and can be defined as "formal, explicit linkages between papers" (Garfield, 1979: 1). They therefore create a network of connections which effectively map the spread of ideas. When one publication cites another a link is produced, and this contributes to building up the underlying structure of scholarly communication. Citation analysis is an established method of providing a quantitative measure of idea exchanges (Smith, 1981; Borgman & Furner, 2002; Nicolaisen, 2007).

Ideas may spread extensively within their subject boundaries, drawing citations from multiple closely related journals. But the boundaries between subject areas are not impermeable and cross-disciplinary idea exchanges can also occur, and be reflected by citation analyses. Where ideas, research and methods cross subject boundaries they can be viewed through an economic analogy: as imports or exports (Cronin and Pearson, 1990). Where the citing journal is from a different discipline to the cited journal, a citation can be seen as evidence of an import or export process. By exporting to other subject areas a discipline can potentially increase the academic visibility of its research output.

The discipline of librarianship and information science (LIS) has potential relevance and applicability to a range of other subject areas, because of core topical overlaps (Cronin and Meho, 2008: 4). Citations from external publications are valuable to LIS as they provide a means for it to maximise its influence. Therefore patterns in how LIS ideas are utilised outside of the discipline, and the extent of their influence, form an interesting research area.

Focusing specifically on LIS, the concept of the import and export of ideas has been investigated in an extensive study by Cronin and Meho (2008). The authors carried out a large-scale and long-term analysis of all citations to LIS journals. This provides insights into the subject areas, and specific journals, in which LIS articles are most frequently cited outside of the field. It is assumed that the influence of LIS is strongest on the non-LIS subject areas which 'import' the most- i.e. make the largest number of citations to LIS journals. This perspective fits in with the wider theory in citation analysis that citations are indicators of importance (Smith, 1981: 86), and therefore can function as a measure of scholarly influence. The destinations of LIS exports can indicate which subject areas are drawing most extensively, if at all, on LIS research.

However a direct link cannot necessarily be made between exports and actual level of influence as individual journals do not have a standardised level of perceived authority and significance. Journal impact factor (IF) is a measure which can be used within citation analyses to quantify a particular journal's status (Garfield, 2006; Pendlebury, 2009). It is effectively a ratio between a journal's citation rate and its citation potential (Garfield, 1979: 149). Use of IF allows evaluative studies of research output to go beyond straightforward citation counts. The IF of a citing journal can indicate the level of influence and prestige achieved by the articles it cites. IF is one of several methods for measuring journal status and alternatives have been highlighted by many authors (e.g. Bar-Ilan, 2008; Pendlebury, 2009). However IF is the longest established and the most widely used measure of journal impact, albeit often in conjunction with other methods.

1.2 Rationale

Import-export studies in LIS can potentially be improved by analysing not just the disciplines citing LIS research, but the academic status of the citing journals, as indicated by their impact factors. Whilst IFs have been utilised in a large number of previous bibliometric studies, no existing studies have specifically focused on IF within

an LIS import-export study. This study addresses this gap in the literature and builds on Cronin and Meho's large-scale research into LIS idea exchanges by providing insights into the impact and value of LIS exports. Within the wider field of import-export studies the project contributes to a development of methodologies by implementing and evaluating the application of IF.

1.3 Aim and objectives

Aim

To investigate the influence of LIS exports and the extent to which import-export studies in LIS can be enhanced by incorporating the measure of journal impact factor.

Objectives

- To carry out a literature review providing a contextual background for the themes of the import and export of ideas through citations, and the use of impact factors in citation analysis.
- To identify a body of papers citing high quality LIS research.
- To analyse non-LIS citations to LIS research in terms of the numbers of citations and the impact factors of the citing journals.
- To assess the influence of LIS on external disciplines as indicated by citation counts and journal impact factors.
- To evaluate the application of journal impact factor in LIS import-export studies.

1.4 Project overview

The rest of this dissertation is split into four main sections. The next section presents a review of literature relevant to citation analysis broadly, and also to the specific themes of import-export studies in LIS, and the application of journal impact factor. This provides the context for the present study. Following this is a description and

discussion of the methodology used, including potential limitations. The results of the research are then provided, presented in tables and graphs and accompanied by analysis and discussion. The final section contains the conclusions of the research and directly relates the findings back to the aim and objectives. The implications of the study, and recommendations for future research, are also discussed.

2 Literature Review

2.1 Citation analysis

Citation analysis is the most well-known bibliometric method (Borgman and Furner, 2002: 4). It can be defined as the subsection of bibliometrics which involves studying relationships between citing documents and cited documents (Smith, 1981: 83). More specifically, the goal of citation analysis is to "estimate the varying contributions of scholarly work to the advancement of knowledge" (Neuhaus and Daniel, 2008: 193). Citations are "formal, explicit linkages between papers" (Garfield, 1979: 1). By expressing relationships between the citing and cited documents, citations reflect the structure of scholarly communication. The importance of citations is heightened by the increasing role of computers and networks in scholarly communication as citations become active paths which can be traced through links (Borgman and Furner, 2002: 56). Smith (1981: 84-85) highlights the value of citations as subjects of study due to their unobtrusiveness: user behaviour can be understood without the need to interact with users. Through identifying connections between papers citation analysis provides a quantitative method of evaluating research and ideas. The number of citations received by a publication can facilitate an assessment of its likely resonance and impact in the academic community (Neuhaus and Daniel, 2008: 193).

But the process of creating a citation is not straightforward. Weinstock's (cited in Cronin, 1984: 30) list of 15 reasons why authors cite shows the complexity of the process. As well as paying homage to pioneers and acknowledging related work, these include criticising work, highlighting ineffective work, identifying original publications, and disputing claims. However the relationships established by citations are not universally in the interests of efficient scholarship. Borgman and Furner (2002: 22) criticise schemas detailing the criteria behind citing as being too prescriptive, whereas

in reality citation-worthy works may be omitted, or included works may be of limited relevance.

The applications of citation analysis are particularly broad. Borgman and Furner (2002) distinguish between relational link analysis and evaluative link analysis. Whereas the former indicates relationships and directions of flow, the latter is concerned with using citations to measure "quality, importance, influence, or performance" (Borgman and Furner, 2002: 11). Evaluative studies have been extensively implemented with a wide range of units of analysis. These include the evaluation of documents, people, journals, groups and organisations, and nations, all of which can be measured by their "citedness"- the number of citations or the rate at which these citations occur (Borgman and Furner, 2002: 12). The key limitations of this application of citation analysis stem from the gap between citation in practice and the ideal of scholarly citation. Smith (1981) details several assumptions which underpin evaluative citation analyses, including the assumption that authors have been influenced by the documents that they cite, and that a citation creates a positive link between two documents. Therefore traditional theories of citation are reliant on citations being used to accurately apportion credit, which is potentially a flawed process. Cronin (1984: 26) further highlights the likelihood of inherent inequalities in what citations represent, as citations alone cannot provide additional details about the exact nature of relationships. Conclusions drawn from citation analyses would need to account for these limitations in some way. Smith (1981: 93) argues that "the limitations of citation analysis do not negate its value as a research method when used with care".

Expanding beyond evaluative studies, citation analysis has also been advocated as a means of investigating citation creators as well as the citations themselves. This takes a more interpretative stance towards the act of citing. For example, Nicolaisen (2007) discusses various different theories of citation and concludes that in order to maximise the potential of citation analysis theories need to take account of the motivations behind authors' citation practices. This is also stressed by Liu (1993: 370) who

questions whether citation motives can ever be satisfactorily described without adopting a multidimensional approach which encompasses the reasons behind citing. The complexities in applying citation analysis are effectively summarised by Cronin's (1984: 86) assertion that "citation is not something which happens in a void, and citations are not separable from the contexts and conditions of their generation". These contexts include interactions between different research generators. Cronin and Meho (2008: 551) emphasise a specific application for citation analysis as a "powerful means of mapping the flow of ideas" between disciplines or other research groups. Following on from this, Nicolaisen (2007: 633) cautions against over-psychologising the act of citing, arguing instead that it needs to be recognised as embedded within collective knowledge structures. The composition of individual disciplines and their interactions with each other form an important part of these structures.

2.2 Import-export

Within the field of citation analysis, import-export studies use an economic metaphor to represent the flow of ideas between disciplines. In relation to LIS Cronin and Pearson (1990: 381) define an export as the citation of an LIS author in a non-LIS journal, and this definition can be applied across other academic disciplines. Researchers regularly draw on literature outside of their own discipline, and therefore through examining which papers or ideas are extensively cited by external disciplines it is possible to show how individual disciplines award prestige (Urata, 1990: 312). Furthermore, import-export data has been seen as a measure of the health of a discipline. A dominance of exports over imports suggests a healthy balance of trade, whereas a reliance on imports could imply a stagnating field (Cronin and Meho, 2008: 551).

The economic analogy is emphasised by Cronin and Meho's use of terminology- they use the phrase 'intellectual trading' to describe citation exchanges, and suggest that a healthy discipline will produce "intellectual goods for consumption in both domestic

and foreign (export) markets" (Cronin and Meho, 2008: 552). Guerrero-Bote et al. (2007: 425) also highlight knowledge export as a means of crossing subject category borders, equating subject disciplines with distinct information marketplaces. Goldstone and Leydesdorff (2006: 991) discuss journal-specific import and export "profiles". This shows how import-export studies view citations as a tool for measuring and modelling intellectual performance at a particularly wide, systematic, and process-based level. The parallels between describing citation exchanges and describing economic exchanges are exemplified by Cronin and Pearson's (1990: 385) conceptualisation of ideas as "goods", subject boundaries as "frontiers", refereed journals as "customs and immigration authorities" and external subject areas as "fresh (overseas) markets".

The relationships established by imports and exports reflect levels of disciplinarity across subject areas. Levitt at al. (2011: 1118) place this within a chronological context, identifying an increase in interdisciplinarity over time, and highlighting the development of an interdisciplinary emphasis in research policies as a factor contributing to this. This strong interdisciplinary theme in academic research can be linked with the concept of import-export, as the import and export of ideas is a key contributor to a subject area's level of interdisciplinarity. Therefore literature dealing with interdisciplinarity is of direct relevance to the field of import-export studies and the two phrases can be broadly equated.

Import-export theories have been applied to a broad range of disciplines. Although Levitt et al. (2011: 1119) claim that the hard sciences have received the highest proportion of research into interdisciplinarity, there is also a clear focus on social sciences in the import-export literature. A Japanese study by Urata (1990) incorporated all humanities and social sciences disciplines and found that information flows between individual disciplines are not simply reciprocal but determined by a structural hierarchy. This demonstrates the ability of import-export studies to map out complex interdisciplinary relationships. Levitt et al. (2011) also concentrate on social

science subjects, investigating changes in the level of interdisciplinarity since 1980 for 14 subjects. The methodology incorporates measuring interdisciplinarity by the percentage of citing documents outside the subject area, with Web of Science subject categories used to assign disciplinarity. Other means of classifying disciplines are discussed, including using author affiliation, but WoS subject categories are used due to their ability to facilitate macro-level investigations (Levitt et al., 2011: 1120).

At a smaller scale, Liu and Wang (2005) and Lockett and McWilliams (2005) have analysed citation exports and imports relating to particular subject areas- demography and management respectively. Liu and Wang (2005) highlight demography's particularly interdisciplinary nature due to it drawing from a range of disciplines including sociology, anthropology and geography. By looking at the citation communications made by a body of demography journals they conclude that demography has increased its independence as a discipline as its journals are predominantly communicating within the discipline as opposed to outside it. This shows an alternative interpretation of low import and export levels as an indication of the cohesiveness and individuality of a discipline as opposed to a symptom of academic weakness. Lockett and McWilliams (2005) identify a balance-of-trade deficit between management and related subjects, with the discipline importing more than it is disseminating. However they were primarily examining relationships between management and journals from related social sciences. The most noteworthy citation exchanges in import-export studies are perhaps those that link disparate subject areas. Management is also the focus of an import-export study by Johnson and van Hoek (2010), who investigate citations made by core journals in three sub-disciplines of management: operations, strategy and marketing. This study shows how import-export studies can be used to organise the component parts of a discipline. Operations management was found to draw more from other topic areas than anticipated, leading the authors to suggest that it might form a suitable 'home' for the interdisciplinary-orientated developing sub-discipline of supply chain management.

Showing an even more specific focus, import-export studies have also been carried out at the level of individual journals or articles. Goldstone and Leydesdorff (2006) assess exports from and imports to the journal *Cognitive Science*, a supposedly interdisciplinary title. The most cited and most citing subject areas are shown to be different, but the overall conclusions made are positive. The authors conceptualise *Cognitive Science* as playing "a unique bridging role in efficiently transferring information across psychology, computer science, neuroscience and education" (Goldstone and Leydesdorff, 2006: 991-992). So the effective import and export of knowledge is not just about reciprocal citation exchanges, but also the overall multidirectional flow of knowledge between many disciplines. Focusing on the interdisciplinarity of individual articles, Larivière and Gingras (2010) pull together bibliometric data by investigating the distribution of references made by these articles to journals from other disciplines.

Focusing on LIS a core study is Cronin and Pearson (1990). The authors introduce the concept of import-export trends to LIS. The methodology used in the study focused on collating citations to the work of six major figures in the field. The paper identifies an apparently weak export performance for LIS, although the conclusions are limited by the restricted scope of the methodology as only a very small body of LIS research is utilised. Other approaches to studying the import and export of ideas in LIS include Tang (2004a), who focused on citations to LIS publications from selected years, and Peritz and Bar-Ilan (2002), who limited their citation analysis to the output of a single journal, *Scientometrics*. Their focus is the references made by *Scientometrics,* its imports, as opposed to the more widespread focus on export from LIS. Both Levitt and Thelwall (2009) and Tabatabaei and Beheshti (2008) use highly cited LIS papers as the starting point of their investigations, highlighting potential connections between high quality LIS work and a strong export performance. The exchange of ideas has a significant chronological dimension, as shown by Levitt and Thelwall's conclusion that high quality LIS methods and ideas are often exploited by external subjects many years after their initial publication. Tabatabaei and Beheshti's work points towards an overall

increase in the significance of LIS's contributions to wider scholarship over time, indicating a further time-based variable affecting import-export channels.

Working with a significantly larger body of data Odell and Gabbard (2008) investigated the interdisciplinary influence of all journals categorised by Journal Citation Reports as 'information science and library science' for the years 1996-2004, a total of 67. This study replicates an earlier study (Meyer and Spencer, 1996) which performed a similar analysis for the years 1972-1994. Odell and Gabbard (2008: 560) highlight the vast increases in the share of citations to LIS literature by the disciplines of computer science and business and management. They also stress how the journals with the most 'other-field' citations in 2008 were newer LIS titles not included in Meyer and Spencer's work. These findings emphasise how patterns of import and export can vary across time, and are essentially determined by what is defined as an LIS idea. An even more comprehensive study was conducted by Cronin and Meho (2008). They identify three limitations which characterise earlier import-export studies in LIS: restricting analyses to a set time-period, focusing on a sub-field of LIS, or investigating only a small portion of literature. With the aim of alleviating the effects of these limitations Cronin and Meho (2008) conducted a large-scale citation analysis of intellectual trading between LIS and other disciplines, covering a 30 year period and 275 journal titles. It is concluded that LIS has become both a more successful exporter of ideas, and a greater user of the literature of other disciplines. This contrasts with the more negative conclusion reached by Cronin and Pearson (1990).

Another import-export theme in the LIS literature involves comparative studies of closely related subject areas. Borgman and Rice (1992) carried out a citation study of core journals in the disciplines of information science and communication studies with the aim of establishing any convergence over time between the two disciplines. Similarly Ellis et al. (1999) looked at the relationships between information science and information systems. Despite apparent connections, the pairs of disciplines in each study were found to be distinct as reflected by limited overlap in citation trading. So as

well as a measurement of influence, import-export can also be a used as a means of determining subject boundaries. By comparing the balance of imports and exports across subjects Tang (2004b: 6) concluded that 29 disciplines "hold mutual citation exchange" with LIS and 20 disciplines have "singular citation connections with the field". This is used to support the theory that LIS has become increasingly interdisciplinary over time. It has been argued that the promotion of interdisciplinarity in LIS can improve research quality, based on the finding that the highest cited LIS articles also tend to have another subject categorisation (Levitt and Thelwall, 2009: 57). From this perspective import-export is not just the consequence of high quality research, but also potentially a determining factor. This is reliant on the assumed correlation between high citation rates and high quality being accurate, though. Furthermore, Guerrero-Bote et al. (2007: 435) dispute the organic nature of subject categories, arguing instead that categories are determined largely by practical considerations. For example categories may be subdivided due to their size but still maintain very close relationships which could have the effect of skewing patterns of import and export. This brings into question exactly how to define interdisciplinarity.

The concepts of the import and export of ideas in LIS have not been exclusively investigated through citation-based studies. Holland (2008) stresses the interdisciplinarity of LIS through its collaboration with other disciplines such as computer science or sociology. An argument is presented for the need to distinguish effectively between interdisciplinary and multidisciplinary LIS research in order to maximise the value of collaboration. Chua and Yang (2008) conducted a comparative study of collaboration by analysing all research articles in *Journal of the American Society for Information Science and Technology* and comparing two 10-year time periods. It is concluded that there is an apparent trend towards increased collaboration between authors, including cross-disciplinary collaborations, illustrating the difficulties of delineating LIS as a field. This also suggests difficulties with the identification of imports or exports, as the connections between disciplines may have taken place at the research level, as opposed to just at the dissemination level.

Illustrating a further alternative approach to investigating import-export in LIS, Böll (2007) puts forward the idea that where journals can be attributed to more than one subject area they indicate an overlap between disciplines. Where these overlaps occur, a degree of intellectual trading can be hypothesised. Böll found that the biggest overlap was between LIS and Computing Studies which shared 9.5% of LIS journals. However actual citation analysis would be needed to ascertain how, and indeed if, these subjects are exchanging knowledge beyond just publishing in the same titles.

2.3 Impact factor

Journal impact factor (IF) is "a measure of the number of citations received in a given year by the 'average' paper in a given journal" (Borgman and Furner, 2002: 17). It is a well-established means of determining the prestige of a journal at a more complex level than just citation counting. IFs are calculated by taking the number of citations made in a given year to the journal's content in the previous two years, and dividing this figure by the total number of citable items in that journal in those two years (Pendlebury, 2009: 2). Journal impact factor indicates the "expected impact of a paper published in that journal" prior to the attribution of quality on the basis of citation accumulations (Guerrero-Bote, 2007: 424). The size of a journal inevitably affects the number of citations it receives regardless of its quality, and IF minimises this advantage by showing the average citation rate per published item (Garfield, 1979: 24). Impact factors are published yearly by Thomson Reuters in the Journal Citation Reports database and their primary intention is to be a measure of journal performance, although they are often used controversially to evaluate authors and articles as well (Pendlebury, 2009: 2).

The history and development of IF has been discussed in many papers (e.g. Archambault and Larivière, 2009; Cameron, 2005). Within a detailed review of twenty-first century informetrics Bar-Ilan (2008) stresses the importance of some form of journal ranking, and gives examples of studies which have successfully utilised IFs.

Glänzel (2003: 63-64) outlines the main strengths of IF as a journal citation measure: its independence from journal size, comprehensibility, stability, reproducibility, robustness and fast availability. Further strengths are highlighted by Pendlebury (2009: 3), namely the simplicity of IFs both to calculate and to understand, and the potential for viewing changes over time generated by consistent IF calculations over a large number of years.

However IF is a very controversial tool and its value as an evaluative measure of journal quality has been widely disputed. A key problem raised in the literature relates to exactly what IF is actually measuring. Franceschet (2010: 55) distinguishes between measures of popularity and measures of prestige, arguing that IF belongs to the former category. Coleman (2007) claims that IFs are too restricted in scope and that a broader model of assessment focusing on value is needed. In terms of the application of IF, its appropriateness for measuring journals, but not individual researchers or articles, has been noted (Bar-Ilan, 2008: 23). One of the major themes relating to IF is its relationship with the categorisation of academic subjects. IF calculations have been shown to benefit some fields disproportionately meaning that comparisons between separate journals or fields will be biased (Gómez-Sancho and Mancebón-Torrubia, 2009). This is because citations are affected by the size of the discipline, its citation habits, and the size of the reference list in a typical article (Guerrero-Bote et al., 2007: 424). Because of this higher citation is potentially primarily linked to the citation-intensive disciplines and not necessarily to the intrinsic quality of an article itself (Larivière and Gingras, 2010). Additionally, IF is not an applicable measurement to humanities subject areas where books are the main form of scholarly communication (Pendlebury, 2009: 4), and so it cannot be applied universally across all disciplines. Garfield (2006) refutes some of the criticisms levelled against IF and argues that although not perfect, it is still a very valuable measure.

A range of modifications to IF have been proposed with the aim of reducing its biases and inaccuracies. Gómez-Sancho and Mancebón-Torrubia (2009) see the application of

a normalisation or standardisation process as essential to make impact factor a valid comparative measure. They propose a weighting system as a means of achieving a more neutral measure of journal impact. Wong et al. (2010) also stress the limitations of IF when dealing with citations from a range of different disciplines. In this study a 'contribution to impact' factor is calculated from the original IF values in order to provide a normalised measure of the citation impacts of the target articles in the study. With the aim of improving reliability and validity when quantitatively analysing research performance, Pendlebury (2009: 7-9) proposes the 'ten commandments' of citation analysis. Point number seven, "obtain multiple measures" shows how IFs can also be normalised through comparison with other measures.

A strong link between IF and interdisciplinarity is evident in the literature. Larivière and Gingras (2010) investigate the effect of interdisciplinarity on the level of impact an articles is able to achieve. Their findings suggest that to maximise impact there is an optimum level of interdisciplinarity, with scientific impact reducing where interdisciplinarity is at the higher or lower end of the spectrum. This suggests that the nature of citation trading between subject areas could ultimately determine an article's prestige, as opposed to the other way round. This is supported by Seglen (1994) who found no support for the assumption that articles generally become highly cited as a result of being published in high impact journals. Both articles emphasise that the relationships between IFs and citation practices are by no means predetermined or straightforward.

On a similar theme Guerrero-Bote et al. (2007: 425) hypothesise that the export of knowledge will have a definitive influence on the distribution of IFs within a subject category. The hypothesis was shown to be correct with high levels of import and export leading to increased visibility for particular disciplines, enabling the most cited papers to gain even more citations, and widening the gap between the highest and lowest impact journals in the category. Using JCR subject categories to identify the IF distribution of separate subject disciplines can be problematic, though. Pendlebury

(2009: 4) criticises JCR subject categories as being too subjective and overlooking many subfield variations.

IF is not the only means of measuring the scientific impact of a publication. Larivière and Gingras (2010: 128) also utilise citations received by articles and the percentage of articles in the top 5% most cited articles as additional indicators of quality, illustrating some alternatives to IF. A separate bibliometric tool for measuring research quality, Journal Diffusion Factor (JDF), is introduced by Rowlands (2002). Its intention is to measure the "'breadth' of the reception of a particular journal in the marketplace for ideas" by calculating the "average number of citing journals per 100 source citations within a given time window" (Rowlands, 2002: 79). Rowlands highlights a significant correlation between JDFs and exports, meaning that JDFs can potentially provide a measurement of a journal's likely export performance. However it is stressed throughout that no single measure of scientific impact is all-encompassing. JDF in no way supersedes impact factor, it instead offers a complementary form of analysis. Other suggested measures of research quality include electronic journal usage data (Bar Ilan, 2008: 18) and peer ranking of best articles (Walter et al., 2003). Bar Ilan (2008: 18) also emphasises a recent increase in interest in broad scientific excellence instead of specific performance metrics, which further points to the theme of combining multiple measures. However due to the easy accessibility of IFs from the Journal Citation Reports database they perhaps remain the most practical single measure to use, especially as their validity can be increased by adapting or normalising raw values.

3 Methodology

3.1 Approach

To meet the dissertation aim a methodology was required which implemented an investigation of exported ideas from Librarianship and Information Science (LIS), and incorporated this with journal impact factor (IF) as a measure of the value of these exports. This was achieved through identifying and analysing cross-disciplinary citations to high quality LIS papers, and then assessing the IFs of the citing publications. As demonstrated in the preceding literature review, citation analysis has been successfully used as a means of mapping the flow of ideas in multiple previous studies. Citation analysis provides a quantitative means of assessing how LIS ideas are spreading to other disciplines. Using this strategy enabled exports from LIS to be efficiently identified and evaluated- publications citing the LIS articles could be assessed by their subject discipline (are they external to LIS?), and their IF (do they represent high or low value exports?).

The methodological background is drawn from two key papers- Cronin and Meho (2008) and Wong et al. (2010). Cronin and Meho (2008) conducted a large-scale longitudinal study of all citations to and from a population of 275 LIS publications over a 30 year period. The aim was to assess intellectual trade within the field of LIS. This study used a similar citation analysis strategy to study idea exchanges, albeit on a smaller scale. Although Cronin and Meho investigated both exports from and imports to LIS, this study focused primarily on export patterns, which were then further analysed in terms of their quality. This was to meet the objective of assessing the wider influence of LIS, as opposed to its overall balance of trade. Additionally, a parallel investigation of imports to LIS would have been unachievable within the

available time. Cronin and Meho's use of Web of Science subject categories was adopted as a means of assigning disciplinarity to citing publications.

The study by Wong et al. (2010) is significant to this study as it utilised IF within a citation analysis of the Cambridge Structural Database (CSD). The study aimed to "quantify the impact of the CSD on academic research" (Wong et al., 2010: 811), and this was achieved by calculating 'contribution to impact' values based on the IFs of citing publications. This allowed the value of a citation to be measured in a way that accounts for both quantity and quality. Following on from this, import-export studies can potentially improve their scope and significance by similarly implementing IF as a measurement of export quality and value. Not all citations can be considered equal, and the value of an export is determined to a large extent by the journal importing it. An export to a high impact journal is of greater value than an export to a journal with a limited impact. The present study investigates the nature of these export patterns specifically in relation to the field of LIS.

The methodological approach outlined was practical to implement as citation data and IF figures are readily available through the Web of Science (WoS) Cited Reference Search and Journal Citation Reports (JCR) respectively. The WoS subject categorisations required to identify non-LIS citations are assigned to each journal and easily extractable from a list of citing documents downloaded from the Cited Reference Search.

3.2 Formulating a sample of LIS papers

In order to make the study fit the available time-frame it was necessary to establish a sample of LIS papers of a manageable size. All citations to the sample could then be collated and analysed, enabling the full range of exports from this portion of LIS research to be included. To create a delineated sample, papers submitted by UK LIS departments as part of the 2008 Research Assessment Exercise (RAE 2008) were used.

The purpose of RAE 2008 was to "produce quality profiles for each submission of research activity made by institutions" (Research Assessment Exercise, 2008), which could then be used to determine funding. Full details of all the research submitted by each institution are available on the RAE 2008 website (www.rae.ac.uk), and can be navigated by subject category. A core benefit of exploiting this collection of research was its easy accessibility. Furthermore, using RAE 2008 submissions ensured that the LIS papers used in the study represent what should be the highest quality work in the field. An initial sample of high quality LIS research was necessary for the study to meet objective number two: 'to identify a body of papers citing high quality LIS research'. Because of the assumed quality of the LIS sample a significant quantity, and quality, of exports could be anticipated. Therefore through using highly citable LIS articles the sample aimed to facilitate a thorough investigation of LIS export performance.

The RAE 2008 website lists 21 institutions under the Unit of Assessment (UoA) 'Library and Information Management'. To cover all of these was not possible due to time constraints. Also, not all the institutions listed have departments which can be considered to fall fully within the category of LIS. For example Brunel's department is more orientated towards information systems and computing, reflecting how the UoA attracted submissions from areas such as information systems and humanities computing, not just traditional LIS departments. To ensure that the study used core LIS research a shortlist of institutions was compiled through analysing the 'research environment and esteem' section of each institution page under the library and information management UoA. This section provides details of aspects of the department such as its format, staff, research strategy, achievements, and particular interests. The following 10 institutions were selected as representing departments situated most centrally within the subject area of LIS:

- Aberystwyth University
- University of Brighton
- City University

- Leeds Metropolitan University
- Loughborough University
- Manchester Metropolitan University
- Robert Gordon University
- University of Sheffield
- University College London
- University of Wolverhampton

The numbers of papers submitted differed between the ten departments depending on staff numbers and the eligibility of staff and research. Up to four items could be submitted for each individual (Research Assessment Exercise, 2005: 18). Within the total quantity of research submitted by each of the ten departments listed above, the submissions used in the study were limited to articles, excluding conference papers, book chapters, or other publication forms. This was to ensure a focus on journal publications, for which Web of Science and Journal Citation Reports provide coverage. Table 1 summarises the RAE 2008 article submissions used to form the LIS research sample. The total number of article submissions made by each institution was progressively reduced to form the final sample. This is because not all of the LIS articles were available through Web of Science, and not all of those which were available had been cited.

***Table 1**: Composition of the LIS research sample*

Institution	RAE 2008 article submissions	... available in WoS	... with at least one citation (final sample)	Submissions date range
Loughborough	99	60	51	2001 – 2007
Sheffield	71	55	53	2001 – 2007
UCL	42	27	24	2001 – 2007
City	40	29	25	2001 – 2007
Robert Gordon	33	17	13	2001 – 2007
Aberystwyth	31	23	18	2001 – 2007
Manchester Met	31	16	15	2001 – 2007
Leeds Met	29	16	13	2001 – 2007
Wolverhampton	16	16	15	2002 – 2006
Brighton	13	5	5	2001 – 2007
Total	**405**	**264**	**232**	2001 – 2007

3.3 Justifying the use of WoS Cited Reference Search

The Web of Science Cited Reference Search has been extensively used in citation analysis studies, including Cronin and Meho's (2008) import-export study. The WoS database covers over 9,000 journals worldwide and allows single searches across the three citation indexes it collates- science, social sciences, and arts and humanities. Within WoS, the Cited Reference Search function allows a target article to be input and all publications citing this article to be identified. It is possible to carry out similar citation searches with other tools, most notably Scopus and Google Scholar. The relative merits of each have been discussed in papers including Jacso (2005) and Neuhaus and Daniel (2008). Scopus has no coverage of arts and humanities, and restricted coverage of social sciences (Jacso, 2005), whereas Web of Science fully spans all disciplines. Google Scholar's main limitations are its questionable subject and resource coverage and the lack of structured facilities for browsing, searching, and saving results (Neuhaus and Daniel, 2008). Web of Science was used in this study for two main reasons. Firstly, because it provides comprehensive support tools for organising and analysing results. Secondly, because it was used as the basis of both

Cronin and Meho's previous study of import-export in LIS, and the study by Wong et al. which specifically implemented impact factors.

3.4 Data collection pilot

To inform the specifics of the full data collection strategy the method was piloted using the RAE 2008 LIS submissions from one institution- Aberystwyth (18 article submissions). This allowed the details of the data collection and management process to be established and any potential problems to be identified. The main findings and issues which emerged from the pilot are summarised below.

Restrictions to the dataset

The scope of WoS and JCR imposes certain restrictions. As already highlighted, the LIS articles used to conduct citation searches were necessarily limited to those which were indexed by WoS. For Aberystwyth, eight out of the 31 original articles submitted for the RAE 2008 assessment were not available in WoS meaning citation information could not be accessed. A further five articles had no citations leaving a final sample size for this institution of 18. The body of citation data itself was also restricted to citing articles which were available in both WoS and JCR (so that impact factors could be obtained), and which had subject categories (so that exports could be identified). It was found from the Aberystwyth data that coverage did not always fully overlap, meaning there were no IFs for some citing publications. Due to the necessity for both citation data and corresponding IFs, it was clear that a significant quantity of the potential dataset would be inaccessible. It was also found that some of the LIS articles yielded very small numbers of citations, possibly due to their relatively recent publication. However it was reasoned that this should be countered by the substantial size of the original sample of submissions, and that the combined group of citations to articles from all institutions should be sufficient to facilitate meaningful analyses.

Downloading and storing results from WoS Cited Reference Search

Through experimenting with the Aberystwyth data it was established that results from WoS Cited Reference searches could be downloaded and saved as text files and then imported directly into Excel spreadsheets, complete with field headings. Only citing journal articles were required by the study (as they could be matched with impact factors) and it was discovered that search results could be pre-filtered to achieve this. Overall the pilot demonstrated that Excel spreadsheets were an efficient and practical way to manage citation data as they can be easily sorted and manipulated.

Subject categories

WoS subject categories were used by the study to determine whether or not citing articles were external to the discipline of LIS. Using the Aberystwyth data it was ascertained that spreadsheets of citing documents could be sorted according to the subject category field as a straightforward way of picking out external citations. An issue arising from the pilot, though, was that many journals have more than one subject category making the identification of exports more complex. Where journals are classified as LIS ('Information Science & Library Science' in WoS terminology) alongside another subject area they reflect both exports and internal citations. Therefore there were potentially two levels of exports to take into account.

Timings

Through conducting the data collection pilot it was possible to provide accurate time estimates for the completion of the data collection stage of the project, and to establish that it was feasible.

3.5 Full data collection process

The overall data collection methodology was developed from the pilot study. The process falls into two stages: accessing citation data, and accessing impact factor data.

3.5.1 Accessing citation data

Carrying out citation searches

Within Web of Science Cited Reference Search searches were conducted for each of the LIS articles in the sample using the 'cited author', 'cited work' and 'cited year' fields. Searches were limited to the publication type 'J' (journal), so that only citing journal articles were retrieved. Where searches did not yield any results a conventional search for the target article was carried out to provide a back-up check for citations. LIS articles in publications not covered by WoS, and those in WoS but without any citations, were not further utilised in the study. Citation counts for each article were recorded alongside their bibliographic details in an Excel spreadsheet.

Downloading results

For each of the LIS articles in the sample, the results list of citing articles from WoS Cited Reference Search was exported to an Excel spreadsheet using the 'output records' function. Separate spreadsheets were maintained for each of the 10 LIS institutions. Once all citation searches were completed, these spreadsheets provided full bibliographic information on all citing journal articles.

Extracting and defining exports

Each individual spreadsheet was sorted by subject category in order to roughly group the citing articles according to their subject origin. Any articles which did not provide subject categories were discounted. From these initial spreadsheets all full exports were extracted and pasted into a single spreadsheet, which then contained all details of all non-LIS articles citing the sample of LIS articles. Full exports were defined as citations from journals entirely without the WoS LIS categorisation. Alternatively, part exports were defined as citations from journals categorised as LIS alongside one or more other subjects. The focus of the subsequent data analysis was exclusively on full exports. This was to ensure a concentration on the objective of assessing the influence of LIS on external disciplines. It was found that a large number of journals classified as LIS were also classified as Computer Science, Information Systems. Examples are

Journal of Information Science, *Aslib Proceedings* and *Journal of the American Society for Information Science & Technology*). Whilst the study defines citations in these journals as part exports due to their computer science categorisation, they cannot really be regarded as cross-disciplinary citations.

***Table 2**: Breakdown of citations for each LIS institution*

Institution (no. of articles included)	Total citing documents	... of which are journal articles	... with at least one WoS subject category given	... with at least one category external to LIS (part exports and full exports)	... with all categories external to LIS (full exports)
Loughborough (51)	265	242	236	138	64
Sheffield (53)	974	847	839	780	665
UCL (24)	197	180	171	114	42
City (25)	396	327	321	292	164
Robert Gordon (13)	38	33	33	17	7
Aberystwyth (18)	312	281	279	187	24
Manchester Met (15)	99	92	91	63	24
Leeds Met (13)	64	52	51	46	27
Wolverhampton (15)	290	254	254	223	46
Brighton (5)	125	116	116	107	95
Total	**2760**	**2424**	**2391**	**1967**	**1158**

3.5.2 Accessing impact factor data

In order to quantify the value of exports impact factor (IF) figures needed to be gained for all the citing publications. This was achieved using the Journal Citation Reports (JCR) database. JCR collates citation data from over 11,000 journals and provides IF figures for these publications. IFs give an average citation rate for the JCR year, based on articles from the previous two years. Average IFs for each subject category are also provided. The most recent JCR year is 2010. Five-year IFs are also available, taking into

account articles published in the previous five years. This study used two-year IFs as they reflect JCR's primary measure. They are also the most widely used due to five-year IFs being unavailable for JCR years prior to 2007.

To obtain IF figures for the citing journals JCR searches were conducted by journal title using the 'search for a specific journal' option. JCR contains a Science Edition and a Social Sciences Edition which are searched separately. It was necessary to check both editions as categorisation of publication titles was not always clear. IF figures were added to the collated full exports spreadsheet. JCR does not cover the full range of WoS journals and so there were some export publications which could not be assigned IFs. Table 3 shows the availability of IFs for the documents citing full exports from LIS.

***Table 3**: Availability of impact factors (IFs) for articles citing full exports*

Institution	Citing documents (all exports)	Citing documents (part exports)	Citing documents (full exports)	... with IF figures available
Loughborough	138	74	64	63
Sheffield	780	115	665	614
UCL	114	72	42	23
City	292	128	164	159
Robert Gordon	17	10	7	4
Aberystwyth	187	163	24	22
Manchester Met	63	39	24	21
Leeds Met	46	19	27	20
Wolverhampton	223	177	46	44
Brighton	107	12	95	91
Total	**1967**	**809**	**1158**	**1061**

As discussed in the literature review section some form of normalisation was needed to make IFs comparable across subject categories. Wong et al. (2010) developed a 'contribution to impact' figure which "provides a normalized measure of the citation impacts of the target articles" (Wong et al., 2010: 817). The key method used to acquire these normalised IFs was to divide a raw IF value by a mean IF value. The present study adopted a similar approach to normalisation by dividing IF values by the

average IF for their subject category. Full details of this normalisation process are provided in section 4.3.1.

3.6 Analysing citation and impact factor data

Citation counts

The publications citing full exports from LIS were analysed according to the number of citations they made. The spreadsheet containing details of all citing articles was sorted by journal title. By grouping all citations from the same journal in this way it was possible to generate a citation count for each unique journal title. Citation counts were also calculated for each individual subject category assigned to the citing journals. A list of all subject categories was obtained from JCR. Once collated, citation counts were used to rank both citing journals and citing subject areas.

Impact factors

The citing journals were then analysed in terms of their normalised impact factors (NIFs). NIFs were used to rank citing journals and to ascertain which LIS exports had the greatest value and potential impact.

Combining citation counts and impact factors

Citation counts were then plotted against normalised impact factors to determine the shape of the NIF distribution, and the extent to which LIS exports could be considered to be above average in terms of value.

3.7 Limitations

The project was limited by the need to select a restricted sample of LIS articles in order to make the research achievable in the available time. Only research submitted by LIS departments to the 2008 Research Assessment Exercise was considered, and this was further limited to just articles. This means that whilst the articles used should be of

high quality, they are not necessarily fully representative of LIS ideas. Through only investigating a portion of the total LIS research output some high value export channels could be overlooked.

A second significant limitation was the inherent restrictions in the databases used to conduct citation searches and obtain impact factor figures. Although the scope of Web of Science is wide there are some publications which it does not cover, preventing the inclusion of some of the LIS research in the study. Additionally, Journal Citation Reports only covers science, technology, and social sciences subjects, so where citing journals fell within other categories impact factors were unattainable. For a fully conclusive study all citing documents, and their respective impact factors, would need to be accessible for the entirety of the sample.

Thirdly, the results of the study are dependent on the way the methodology has defined an LIS export. Although Web of Science subject categories provide a practical way of determining which disciplines are making citations, the boundaries they imply may not fully reflect scholarship in practice. For example, a citation in a journal categorised as non-LIS may have other connections to LIS research and therefore represent less of an export.

4 Results and Discussion

4.1 Citation data

Citation searches were completed for each of the 10 institutions forming the sample of LIS articles. Within the institutions, the publications used were limited to those which were journal articles, were available within Web of Science (WoS), and had received at least one citation according to WoS Cited Reference Search. This was a total of 232 articles. Details of the citing documents for each of these articles were downloaded from WoS Cited Reference Search and collated into spreadsheets for each institution. This initial body of data was progressively reduced by the removal of references which were not journal articles, or which did not provide WoS subject categories.

Following this process 2391 citing documents remained. From these, those which could be classified as exports from LIS were identified by looking at their WoS subject categories. 1233 documents were placed within the LIS category (51.6% of all citing journal articles with WoS categories). 809 of these (33.8% of all citing journal articles with WoS categories) also had at least one other subject classification and these citations can be regarded as part exports. Example journals citing part exports are *Journal of Computer-Mediated Communication* (classified as Communication; Information Science & Library Science), and *Journal of Management Information Systems* (classified as Computer Science, Information Systems; Information Science & Library Science; Management). The remaining 1158 documents (48.4% of all citing journal articles with WoS categories) did not include the LIS subject categorisation and therefore these citations represent full exports from the discipline of LIS to other subject areas. Examples include *Applied Artificial Intelligence* (classified as Computer Science, Artificial Intelligence; Engineering, Electrical & Electronic), and *Journal of Risk Research* (classified as Social Sciences, Interdisciplinary). Impact factor (IF) figures were

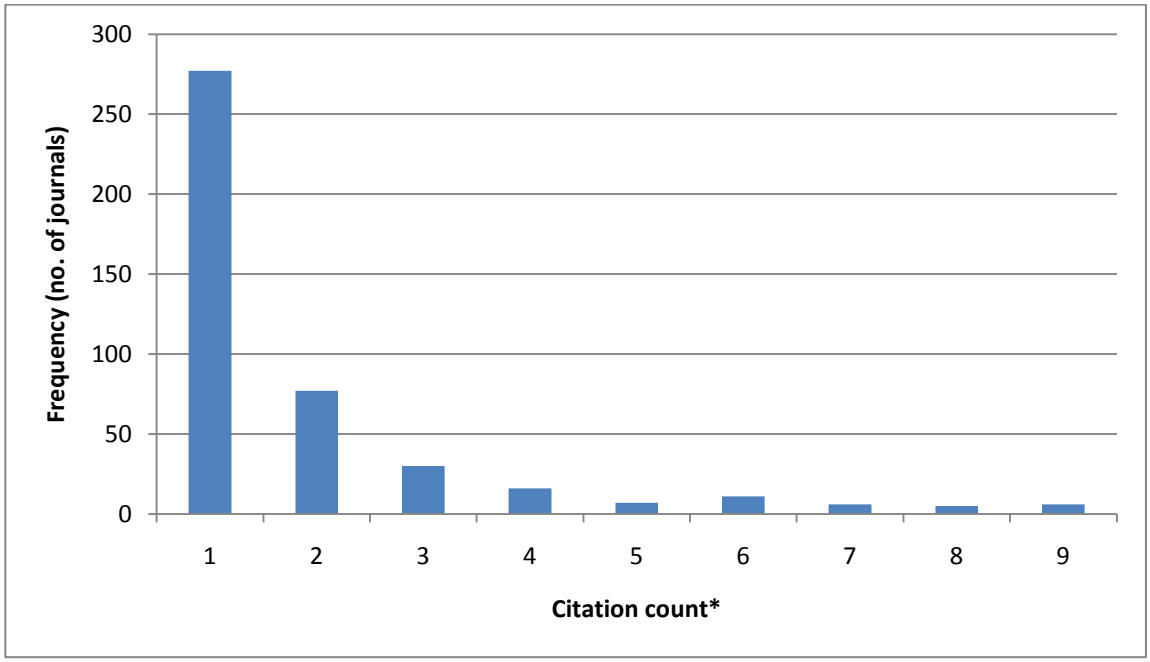
obtainable from Journal Citation Reports (JCR) for 1061 of the 1158 articles citing full exports. These articles form the final body of full export citation data on which the following analyses concentrate. In the remainder of this section the phrases 'citing journals' and 'citing articles' are used to refer to these full export citations.

4.2 Evaluation by citation count

4.2.1 Distribution of citation counts

The 1061 full exports were cited in 444 unique journal titles. Figure 1 demonstrates the distribution of citation counts across these journals. A clear majority of 277 titles (62.4%) made only one citation to an LIS export. The distribution then drops steeply with 77 journals (17.3%) making two citations, and less than half that (30 journals, 6.8%) making three citations. Citation counts of 10 and above (not shown on the graph) are intermittent and frequencies are all of two or less. These patterns illustrate a characteristic long-tailed distribution. LIS exports are thinly spread across the citing journal titles as opposed to a core body of journals importing heavily from LIS. Exports are predominantly being cited a small number of times in a large number of different journals, and a large number of times in a few isolated titles.

***Figure 1**: Distribution of citing journals by citation count*



*Data points not represented: 10,1; 11,2; 14,1; 16,1; 18,1; 22,1; 26,1; 111,1

The wide range covered by the citing journals is exemplified by the variety of titles making just one or two citations. These cover many subjects without conventional connections to LIS, and are often highly specific. For example, *Journal of Air Transport Management* cites an article from Aberystwyth's C.J. Urquhart titled 'Critical incident technique and explicitation interviewing in studies of information behavior' (Urquhart, 2003). The article is cited as background to the use of the critical incident technique (Chang and Yang, 2008) showing an export of methodological practices from LIS. Two articles on clinical librarianship in the UK written by J. Harrison (Loughborough) are cited in the journal *Surgical Clinics of North America* in the article 'Librarians, surgeons and knowledge' (Knight and Brice, 2006). This demonstrates how titles with quite a specific focus are drawing on LIS research when they address the use of knowledge in their discipline. LIS's emphasis on research practices is also influencing other disciplines. This extends to the development of particular industrial techniques, for example *Australian Journal of Agricultural Research* cites an LIS article on practice-based research in networked learning (Levy, 2003) within an article on optimisation in the Australian sugar industry (Higgins et al., 2004). Further titles demonstrating the

varied destinations of LIS exports include *Annals of Tourism Research, Journal of Plant Nutrition and Soil Science,* and *Palaeontology*.

4.2.2 Top citing journals by citation count

Despite the dominance of single citations, amongst the 37.6% of journals which made at least two citations some significantly high counts are present.

***Table 4**: Top ranked citing journals by citation count*

Rank	Journal title	Citation count
1	JOURNAL OF CHEMICAL INFORMATION AND MODELING	111
2	JOURNAL OF MEDICINAL CHEMISTRY	26
3	JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN	22
4	DRUG DISCOVERY TODAY	18
5	COMBINATORIAL CHEMISTRY & HIGH THROUGHPUT SCREENING	16
6	QSAR & COMBINATORIAL SCIENCE	14
7	COMPUTERS & EDUCATION	11
	CURRENT MEDICINAL CHEMISTRY	11
8	CURRENT OPINION IN DRUG DISCOVERY & DEVELOPMENT	10
9	CURRENT COMPUTER-AIDED DRUG DESIGN	9
	EXPERT OPINION ON DRUG DISCOVERY	9
	EXPERT SYSTEMS WITH APPLICATIONS	9
	JOURNAL OF ADVANCED NURSING	9
	MINI-REVIEWS IN MEDICINAL CHEMISTRY	9
	NEW MEDIA & SOCIETY	9
10	COMPUTERS IN HUMAN BEHAVIOR	8
	CURRENT OPINION IN CHEMICAL BIOLOGY	8
	CURRENT TOPICS IN MEDICINAL CHEMISTRY	8
	INFORMATION RETRIEVAL	8
	SOCIOLOGY OF HEALTH & ILLNESS	8

Table 4 shows that the highest ranked journal is *Journal of Chemical Information & Modeling* which made 111 citations to articles in the LIS sample. This is a clear outlier in terms of citation trends as the next highest ranked journal has a proportionally much smaller citation count of 26 (*Journal of Medicinal Chemistry*). Citation counts are then fairly evenly distributed down to the 10th highest value (eight citations). Citation

counts of nine and eight were achieved by six and five journals respectively. This reflects the start of the dramatic increases in journal numbers as citation counts fall.

There is a clear emphasis on scientific journals amongst the highest citers with 15 of the 20 titles appearing in table 4 having chemistry- or medical-related foci. The remaining five are titles that are perhaps more expected importers of LIS ideas: *Computers & Education*; *Expert Systems With Applications*; *New Media & Society*; *Computers in Human Behavior*; *Information Retrieval*. The ranking shows that at the journal level, importing from LIS occurs within some highly specialised titles. Social science and computer science journals, though present, do not have the dominance over citation counts that might be expected.

However citation counts alone can be a misleading indication of export performance. The 111 citations made by *Journal of Chemical Information & Modeling* were all to LIS articles from the same institution (Sheffield) and only covered 11 unique articles. This reduces the initial impression of a strong export performance to this title, as the high citation count results from citations to a small number of core articles, rather than a broad range of LIS research. In fact, all of the chemistry orientated journals in table 4 are citing Sheffield articles. This shows how the particular research strengths of LIS departments can affect the nature and volume of their exports, skewing the citation count rankings. Institution-specific exports are not limited to chemistry journals, though. For example, all of the citations made by *Information Retrieval* were to articles from City. The eight citations made by *Sociology of Health & Illness* were not only to the same institution (Brighton), but also to the same article (Henwood, F. (2003) 'Ignorance is bliss sometimes. Constraints on the emergence of the "informed patient" in the changing landscapes of health information'. *Sociology of Health and Illness.* 25 (6), 589-607). Therefore whilst a non-LIS journal may import heavily from a specific LIS article, this does not necessarily extend to consistent import-export channels with a wider, related body of LIS research.

Those external journals which draw more widely from LIS potentially represent the strongest export performances for the discipline as a whole. An example of this from table 4 is *Computers & Education* which made its 11 citations to seven different institutions and nine different articles. This suggests an established relationship between the journal and LIS, regardless of particular LIS topics. However this was not the case for most of the top citers- just five of the 20 titles in table 4 were citing articles from more than one institution. Examples of some of these more varied import patterns are *Expert Systems With Applications,* which made nine citations to four institutions and six articles, and *New Media & Society,* which made nine citations to three institutions and seven articles.

4.2.3 Top citing subject categories by citation count

LIS exports were cited across 146 unique subject categories (there are a total of 223 in the JCR database). 33 of these categories (22.6%) were only attributed to one citation. Even when a category featured more than once amongst citing documents citation counts were generally quite low with 101 subject categories (69.2%) assigned to fewer than 10 citing documents. By comparison just eight subject categories had a citation count of 50 or over (see table 5) showing that the majority of external citations made to LIS are concentrated within a relatively small group of subject categories. The dominance of the top categories should not be overestimated, though. 55.8% of the 1061 full exports were assigned to two or more subject categories and so subject citation counts are not representative of a subject's unique journal set.

***Table 5**: Top ranked citing subject areas by citation count*

Rank	Subject category	Citation count	% of total full exports (1061)*
1	Computer Science, Interdisciplinary Applications	216	20.4
2	Chemistry, Multidisciplinary	164	15.5
3	Computer Science, Information Systems	159	15.0
4	Chemistry, Medicinal	105	9.9
5	Pharmacology & Pharmacy	102	9.6
6	Biochemistry & Molecular Biology	72	6.8
7	Public, Environmental & Occupational Health	57	5.4
8	Computer Science, Artificial Intelligence	55	5.2
9	Educational & Educational Research	39	3.7
10	Biochemical Research Methods	38	3.6
11	Health Care Sciences & Services	37	3.5
12	Biophysics	34	3.2
	Computer Science, Software Engineering	34	3.2
13	Communication	33	3.1
	Geography	33	3.1
14	Computer Science, Cybernetics	30	2.8
	Remote Sensing	30	2.8
15	Operations Research & Management Science	28	2.6
16	Ergonomics	26	2.5
17	Engineering, Electrical & Electronic	25	2.4
18	Chemistry, Applied	24	2.3
	Geosciences, Multidisciplinary	24	2.3
	Medicine, General & Internal	24	2.3
	Nursing	24	2.3
19	Management	23	2.2
20	Mathematical & Computational Biology	22	2.1
	Psychology, Multidisciplinary	22	2.1
	Social Sciences, Biomedical	22	2.1

*Percentages not mutually exclusive as many journals are assigned to more than one subject category

The highest ranked subject area was Computer Science, Interdisciplinary Applications which was attributed to 20.4% of all articles citing full exports. This demonstrates a clear link between the disciplines of LIS and computer science with research from the former regularly being exported to the latter. The dominance of computer science sub-disciplines is further reinforced by the rest of the top ranked subjects shown in table 5. Computer Science, Information Systems is predictably high at number three, and Artificial Intelligence, Software Engineering and Cybernetics are also high citers.

As already discussed in relation to journals, chemistry subject areas are particularly prominent. Chemistry, Multidisciplinary is the second highest ranked subject area with 15.5% of the total full exports (164 citations), and Chemistry, Medicinal is also attributed to over 100 citations. Numerous medical-related subject categories also feature highly in terms of citation counts. Examples are: Public, Environmental & Occupational Health; Health Care Sciences & Services; Medicine, General & Internal; Nursing. LIS articles on scientific information seem to be particularly exportable, perhaps reflecting overall higher citation rates and different citation patterns in science disciplines.

Focusing on social science subjects the highest ranked subject area is Education & Educational Research which was attributed to just 3.7% of full exports, quite a small value in comparison with the highest citing subjects. Communication and Management, two other subjects expected to have strong relationships with LIS, also feature in table 5. This confirms a reasonable, but not particularly strong, export performance from LIS to related social sciences.

4.3 Evaluation by impact factor

4.3.1 Normalisation of impact factors

In order to most accurately use impact factors to assess the quality of citing publications it was necessary to normalise raw IF values to take into account differing citation trends across subject areas. This enabled IFs from multiple disciplines to be cross-comparable. Two methods of normalisation were devised. These use two different subject IF averages which are provided by JCR: the median IF (middle IF value for the subject category) and the aggregate IF (sum of all citations to journals in the category divided by the sum of all articles in the category). Normalisation was carried out by dividing a journal's raw IF by the average IF (either median or aggregate) for the

subject category assigned to the journal. The resulting normalised IFs (NIFs) provide an indication of whether a journal is above average for its subject category (NIF is greater than 1) or below average for its subject category (NIF is less than 1).

The two normalisation processes were calculated as follows-

NIF 1 = Journal IF / Median subject category IF
NIF 2 = Journal IF / Aggregate subject category IF

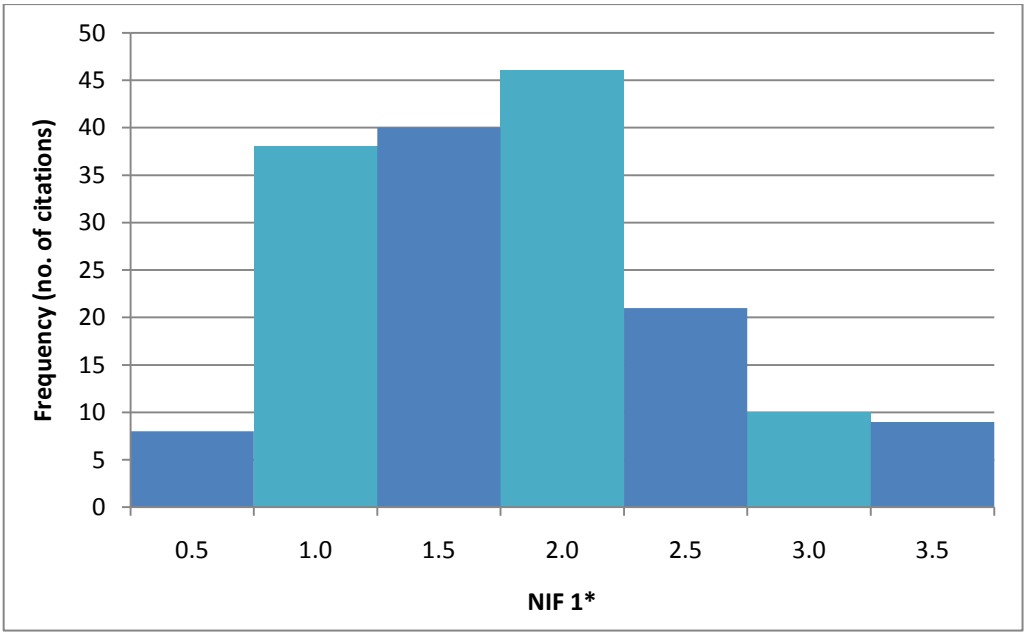
For example the *Turkish Online Journal of Educational Technology* has a raw IF of 1.016. It is attributed to the subject category Education & Educational Research which has a median IF of 0.653 and an aggregate IF of 0.915. Therefore the NIF 1 for this journal is 1.016 / 0.653 = 1.556. This indicates that it is significantly above average for its subject category. Alternatively, its NIF 2 is 1.016 / 0.915 = 1.110. Using this method of normalisation the journal is still shown to be above average, but to a lesser extent.

As approximately half of the citing journals were assigned to two or more subject categories normalisation was not always this straightforward. Where journals were assigned to multiple subject categories a mean of normalised figures for each individual category was calculated. For example *Flavour and Fragrance Journal* has a raw IF of 1.849. It is assigned to two subject categories: Chemistry, Applied (median IF = 1.028) and Food Science & Technology (median IF = 0.930). Therefore its NIF 1 value is ((1.849 / 1.028) + (1.849 / 0.930)) / 2 = 1.893.

It was found that five subject categories did not feature in JCR and therefore corresponding median and aggregate IF values could not be obtained. The categories are: Film, Radio & Television; Humanities, Multidisciplinary; Language & Linguistics; Acoustics; Music. Their absence is likely to be due to their classification as humanities subjects, rather than social sciences, making them outside of JCR's remit. All journals assigned to these categories also had at least one other categorisation, and so normalisation calculations were based on these.

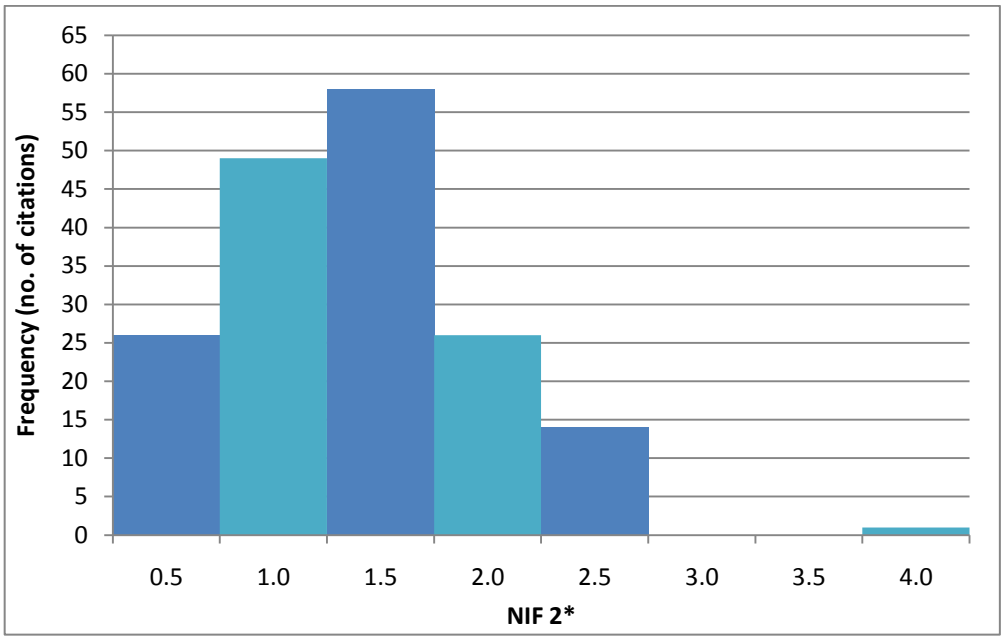
A pilot analysis was undertaken based on citation data for articles from just four LIS institutions in order to compare the distributions produced by the two different normalisation methods (see figures 2 and 3). These two distributions are broadly similar, confirming the reliability of the normalisation process. Due to the time-consuming process of calculating normalised IFs for every citing journal (especially where multiple subjects were involved) it was not possible to carry out both normalisation calculations for the full set of 444 citing journals. For the main analysis NIF 1 values were used, calculated from median subject IFs. In the remaining parts of this section the abbreviation NIF is used to refer to this form of normalisation.

***Figure 2**: Distribution of NIF 1s for four institutions: Aberystwyth, Brighton, Manchester Met and Wolverhampton.*



*NIF 1 axis labels signify upper limits of intervals so 0.5 is 0≤NIF 1<0.5, 1.0 is 0.5≤NIF 1<1, etc.
Data points not represented: 5.5,1; 14,1.

***Figure 3**: Distribution of NIF 2s for four institutions: Aberystwyth, Brighton, Manchester Met and Wolverhampton*



*NIF 2 axis labels signify upper limits of intervals so 0.5 is 0≤NIF 2<0.5, 1.0 is 0.5≤NIF 2<1, etc.

4.3.2 Top citing journals by impact factor

Impact factors for the full export publications range from 0.145 (*Actualite Chimique*) to 33.633 (*Lancet*) and the median IF for citing articles is 2.033. When normalised this range extends to between 0.059 (*Neural Regeneration Research*) and 67.161 (*Science*) with the median value dropping to 1.609. This shows the effect of the normalisation- despite some very high raw IFs, once subject category averages are taken into account the median citing article is less far above average in terms of its potential impact.

***Table 6**: Titles and citations counts (CCs) for top ranked citing journals by raw impact factor (IF) and normalised impact factor (NIF)*

Rank	IF	Journal title*	CC	NIF	Journal title*	CC
1	33.633	LANCET	1	67.161	SCIENCE	1
2	31.364	SCIENCE	1	29.896	LANCET	1
3	28.712	NATURE REVIEWS DRUG DISCOVERY	1	23.483	CHEMICAL SOCIETY REVIEWS	1
4	26.583	CHEMICAL SOCIETY REVIEWS	1	20.923	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2
5	16.729	ANNALS OF INTERNAL MEDICINE	1	14.870	ANNALS OF INTERNAL MEDICINE	1
6	15.617	PLOS MEDICINE	2	13.882	PLOS MEDICINE	2
7	13.471	BRITISH MEDICAL JOURNAL	1	13.721	NATURE REVIEWS DRUG DISCOVERY	1
8	12.73	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	2	11.974	BRITISH MEDICAL JOURNAL	1
9	10.857	ADVANCED MATERIALS	1	11.246	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	2
10	10.639	ARCHIVES OF INTERNAL MEDICINE	1	9.457	ARCHIVES OF INTERNAL MEDICINE	1
11	9.771	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2	8.661	ADVANCED MATERIALS	1
12	9.644	TRENDS IN BIOTECHNOLOGY	1	8.013	CANADIAN MEDICAL ASSOCIATION JOURNAL	1
13	9.312	***CURRENT OPINION IN CHEMICAL BIOLOGY***	8	7.967	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	2
14	9.019	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	2	6.362	PLOS ONE	3
15	9.015	CANADIAN MEDICAL ASSOCIATION JOURNAL	1	6.091	IEEE SIGNAL PROCESSING MAGAZINE	1

16	7.836	NUCLEIC ACIDS RESEARCH	3	5.261	PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A-MATHEMATICAL PHYSICAL AND ENGINEERING SCIENCES	1
17	6.882	AMERICAN JOURNAL OF GASTROENTEROLOGY	1	5.146	TRENDS IN BIOTECHNOLOGY	1
18	6.422	***DRUG DISCOVERY TODAY***	18	5.111	BMC MEDICINE	1
19	6.378	CLINICAL PHARMACOLOGY & THERAPEUTICS	1	4.789	REVIEW OF EDUCATIONAL RESEARCH	1
20	6.326	ACTA CRYSTALLOGRAPHICA SECTION D-BIOLOGICAL CRYSTALLOGRAPHY	1	4.465	IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE	1

*Titles shown in ***bold italics*** also feature in the top ranked journals by citation count (see table 4); titles shown in red are those not featuring in both the IF and the NIF top 20.

There is a large overlap between the IF and the NIF rankings which illustrates the effectiveness of normalisation (see table 6). The top 10 IFs and NIFs are in fact almost exactly the same albeit in a slightly different order. This shows the dominance of these particular journals- they are not only high impact journals but they are also well above average for their respective subject categories. However the top journals, in particular *Science* which has a NIF of 67.161, are clear outliers in comparison with the full spectrum of NIFs. 64.9% of all the 1061 full exports have NIFs of less than two and 97.7% are less than five.

With the exception of *Review of Educational Research*, all of the journals shown in the NIF section of table 6 are science titles, with particular concentrations of chemistry and medicine subjects. The analysis based on citation counts has shown the high level of citations made by journals in these areas, generally to a small body of particularly prominent LIS articles. However those journals with the highest NIFs are not also the highest citers. Table 6 shows that 15 of the top 20 journals by NIF made only one citation to the LIS sample and the remaining five made just two or three citations. The two higher citation counts featuring in the IF ranking, *Current Opinion in Chemical*

Biology (eight citations) and *Drug Discovery Today* (18 citations), are removed from the top 20 once their IFs are normalised. This shows that although LIS is exporting to journals with exceptionally above average levels of impact, these exports are not reinforced by high levels of citing. Nonetheless even disregarding the skew produced by isolated citations from very high impact journals the majority of the citations to full exports (75.2%) are from journals with a NIF of one or above (see table 7). This shows that although export performance may not always be large-scale in terms of high numbers of citations to a variety of LIS publications, LIS research is not simply being exported to below average journals. Instead it is in a position to have a genuine impact outside of the field.

Table 7: *Distribution of citing journals across NIF intervals*

NIF	No. of citations	Above/below average NIF	% of total citations (1061)
0≤NIF<0.5	51	Below average (NIF<1)	24.8
0.5≤NIF<1	212		
1≤NIF<1.5	199	Average or above average (NIF≥1)	75.2
1.5≤NIF<2	227		
2≤NIF<2.5	72		
2.5≤NIF<3	74		
3≤NIF<3.5	176		
3.5≤NIF<4	24		
NIF≥4	26		

4.3.3 Combining impact factors with citation counts

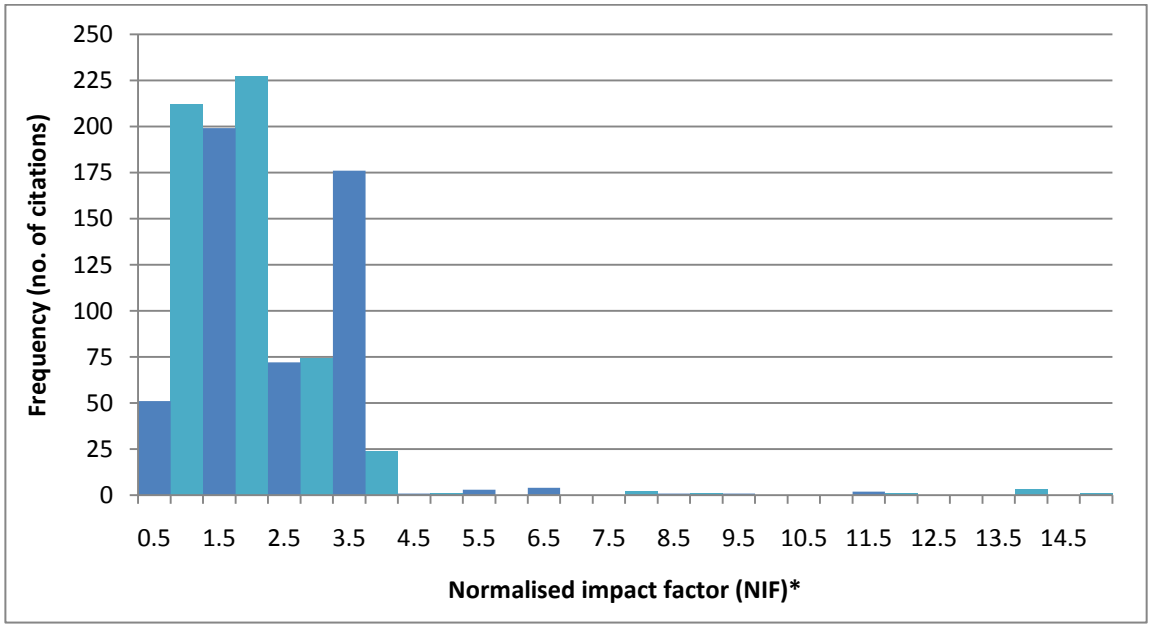
In order to most effectively represent the impact of LIS exports it is necessary to take into account both the impact factors of the citing publications and their respective citation counts. Plotting NIF against citation count allows the distribution of citing documents across NIFs to be illustrated (see figure 4).

The frequency rises dramatically for NIFs greater than 0.5 and peaks at the interval 1.5≤NIF<2 with 227 citing articles falling into this category. After this point the distribution drops steeply and tails off with the exception of the interval 3≤NIF<3.5

which represents a second peak. The highest citing non-LIS publication, *Journal of Chemical Information & Modeling*, falls into this NIF category and so its 111 citations account for much of this uncharacteristic peak. Three other bulk importers are also contributors: *Computers & Education* (11 citations), *Journal of Medicinal Chemistry* (26 citations), and *Current Opinion in Chemical Biology* (8 citations). However the remaining 20 citations in this NIF interval are from 13 separate titles, indicating that there is still a relatively significant range of citing journals with this level of impact.

The shape of the distribution is surprising as it was anticipated that the highest frequencies would occur at the very lowest NIFs, with LIS exporting to primarily low impact journals. Crucially, the trends present are dependent to a large extent on the particular foci of the articles in the LIS sample. These may not be exclusively LIS-orientated, and therefore be more attractive to external subject areas.

***Figure 4**: Distribution of NIF values for all full exports (total = 1061)*



*NIF axis labels signify upper limits of intervals so 0.5 is 0≤NIF<0.5, 1.0 is 0.5≤NIF<1, etc.
Data points not represented: 21,2; 23.5,1; 30,1; 67.5,1

In order to evaluate the potential impact of specific journals in a similarly sophisticated way a score was calculated for each of the citing journals by multiplying their citation count (CC) by their NIF (see table 8). As scientific and medical journals dominate both

the citation count and NIF rankings, titles from these subject areas are almost exclusively the highest scorers in terms of CC x NIF. However the effect of single citations from very high impact journals (for example *Science* and *Lancet*) is reduced albeit marginally, with the list more balanced towards repeated citers. Of course as already highlighted many of these high citers were citing single LIS institutions or even articles, meaning the apparent export performance could be misleading. The strong level of LIS export to the journal *Computers & Education* is reinforced by its high CC x NIF score, along with the fact that the LIS articles it cited were from a range of institutions and authors. Whilst CC x NIF scores allow both measures to be taken into account, there are potentially two other core factors to consider when evaluating the nature of LIS exports- the range of LIS research being cited by importing journals, and the extent to which these cited articles can be regarded as LIS.

***Table 8**: Top ranked citing journals by citation count (CC) x NIF*

Rank	Journal title	CC	NIF	CC x NIF
1	JOURNAL OF CHEMICAL INFORMATION AND MODELING	111	3.310	367.410
2	JOURNAL OF MEDICINAL CHEMISTRY	26	3.265	84.890
3	SCIENCE	1	67.161	67.161
4	DRUG DISCOVERY TODAY	18	2.711	48.798
5	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2	20.923	41.846
6	JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN	22	1.718	37.796
7	COMPUTERS & EDUCATION	11	3.047	33.517
8	LANCET	1	29.896	29.896
9	PLOS MEDICINE	2	13.882	27.764
10	CURRENT OPINION IN CHEMICAL BIOLOGY	8	3.401	27.208
11	COMBINATORIAL CHEMISTRY & HIGH THROUGHPUT SCREENING	16	1.563	25.008
12	CURRENT MEDICINAL CHEMISTRY	11	2.174	23.914
13	CHEMICAL SOCIETY REVIEWS	1	23.483	23.483
14	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	2	11.246	22.492
15	REMOTE SENSING OF ENVIRONMENT	6	3.584	21.504
16	CURRENT TOPICS IN MEDICINAL CHEMISTRY	8	2.578	20.624
17	PLOS ONE	3	6.362	19.086
18	CURRENT OPINION IN DRUG DISCOVERY & DEVELOPMENT	10	1.902	19.020
19	COMMUNICATIONS OF THE ACM	7	2.339	16.373
20	EXPERT SYSTEMS WITH APPLICATIONS	9	1.819	16.371

4.4 Comparing citations to LIS and non-LIS journals

4.4.1 Categorisation of cited journals

The body of articles used to identify exports were defined by this study as LIS research by the fact that they were written by members of LIS departments and submitted by those departments to the 2008 Research Assessment Exercise. However this is not the only way of defining LIS research. Despite being LIS articles, not all of the articles in the sample were actually published in journals categorised by WoS as LIS. Of the 1061 full exports 269 (25.4%) were published in LIS journals, but a much larger figure of 792 (74.6%) were published in non-LIS journals. This raises the question of whether there is any difference between the export performances for these two groups of LIS articles.

4.4.2 Comparing citing subject areas

Tables 9 and 10 show the top subject categories for citations to LIS and non-LIS journals respectively. In the table for LIS journals the dominance of chemistry and related subject areas shown in the overall ranking (table 5) is not present. This suggests that where these subjects are citing highly it is due to LIS research being published in closely related (i.e. non-LIS) journals, as opposed to external subjects importing across more defined subject boundaries. Conversely, Computer Science, Information Systems and Computer Science, Interdisciplinary Applications were high citers for both LIS and non-LIS journals. Therefore LIS is exporting consistently to these subject areas from both within the field's journal body, and outside of it. Similarly Health Care Sciences & Services is consistent in both lists. This subject area has a less direct connection to LIS than computer sciences so it is particularly significant that it is drawing from specific LIS research beyond just that published outside of the field.

***Table 9**: Top ranked citing subject areas by citation count (exports from LIS journals)*

Rank	Subject category*	Citation count	% of total full exports from LIS journals (269)
1	Communication	25	9.3
2	***Computer Science, Information Systems***	22	8.2
3	***Computer Science, Interdisciplinary Applications***	21	7.8
4	Operations Research & Management Science	20	7.4
5	Education & Educational Research	19	7.1
6	***Computer Science, Artificial Intelligence***	17	6.3
7	Engineering, Electrical & Electronic	15	5.6
	Management	15	5.6
8	Computer Science, Software Engineering	13	4.8
	Remote Sensing	13	4.8
9	***Health Care Sciences & Services***	12	4.5
10	Computer Science, Cybernetics	10	3.7
	Ergonomics	10	3.7
	Geography	10	3.7
	Multidisciplinary Sciences	10	3.7
	Nursing	10	3.7
	Psychology, Multidisciplinary	10	3.7

*Those shown in ***bold italics*** feature in the rankings for exports from both LIS and non-LIS journals (tables 9 and 10); those shown in blue feature in the top 10 for all exports (see first part of table 5).

***Table 10**: Top ranked citing subject areas by citation count (exports from non-LIS journals)*

Rank	Subject category*	Citation count	% of total full exports from non-LIS journals (792)
1	***Computer Science, Interdisciplinary Applications***	195	24.6
2	Chemistry, Multidisciplinary	162	20.5
3	***Computer Science, Information Systems***	137	17.3
4	Chemistry, Medicinal	105	13.3
5	Pharmacology & Pharmacy	101	12.8
6	Biochemistry & Molecular Biology	71	9.0
7	Public, Environmental & Occupational Health	50	6.3
8	Biochemical Research Methods	38	4.8
	Computer Science, Artificial Intelligence	38	4.8
9	Biophysics	34	4.3
10	***Health Care Sciences & Services***	25	3.2

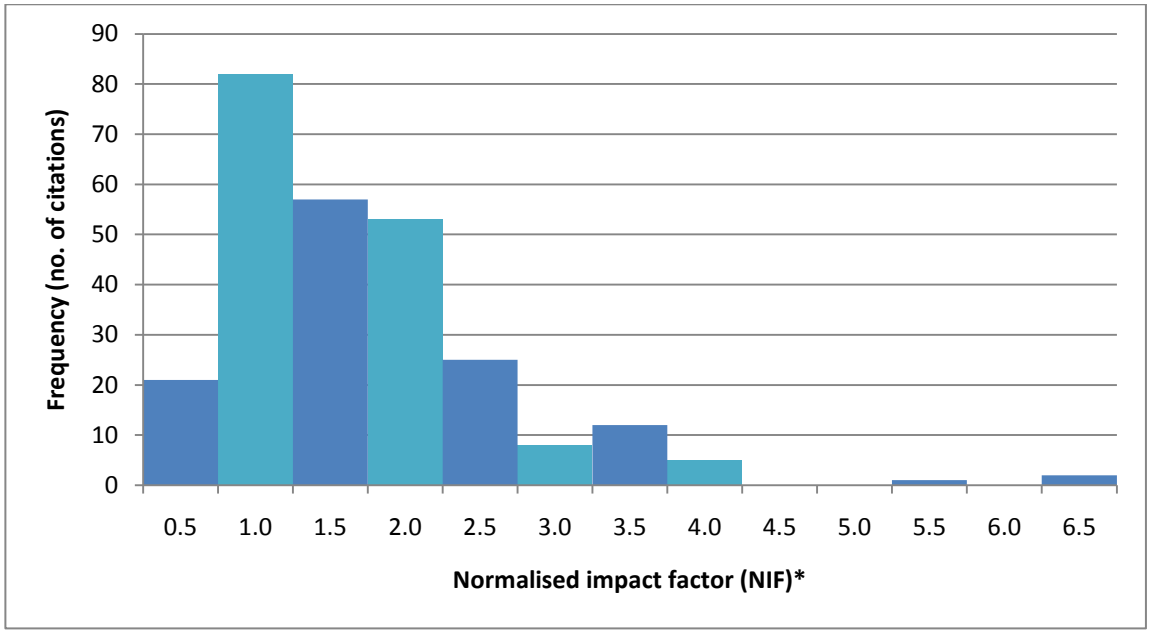
*Those shown in ***bold italics*** feature in the rankings for exports from both LIS and non-LIS journals (tables 9 and 10); those shown in blue feature in the top 10 for all exports (see first part of table 5).

Perhaps representing the strongest export performances are citations from subject areas such as Communication, Education & Educational Research, and Management as these are highly ranked for LIS journals but do not feature in the ranking for non-LIS journals. This suggests that these subject areas are actively importing LIS research and ideas. However looking at the actual citation counts occurring, LIS journals are performing far worse than non-LIS journals. For exports from non-LIS journals 17.3% of citing articles were categorised as Computer Science, Information Systems. For LIS journals this value was just 8.2%, despite the subject area having a similar position in both rankings. The major apparent export trends in terms of volume seem to be bypassing actual LIS publications.

Further illustrating this, there is a huge overlap between the highest citing subject categories for non-LIS journals (table 10) and the highest citing subject categories for the overall group of 1061 full exports (table 5). LIS articles are more likely to be exported successfully to non-LIS disciplines when the article is in a non-LIS journal to begin with. It follows that publishing in a non-LIS journal could be a means for LIS academics to maximise the level of scholarly interest in their research from outside of the field.

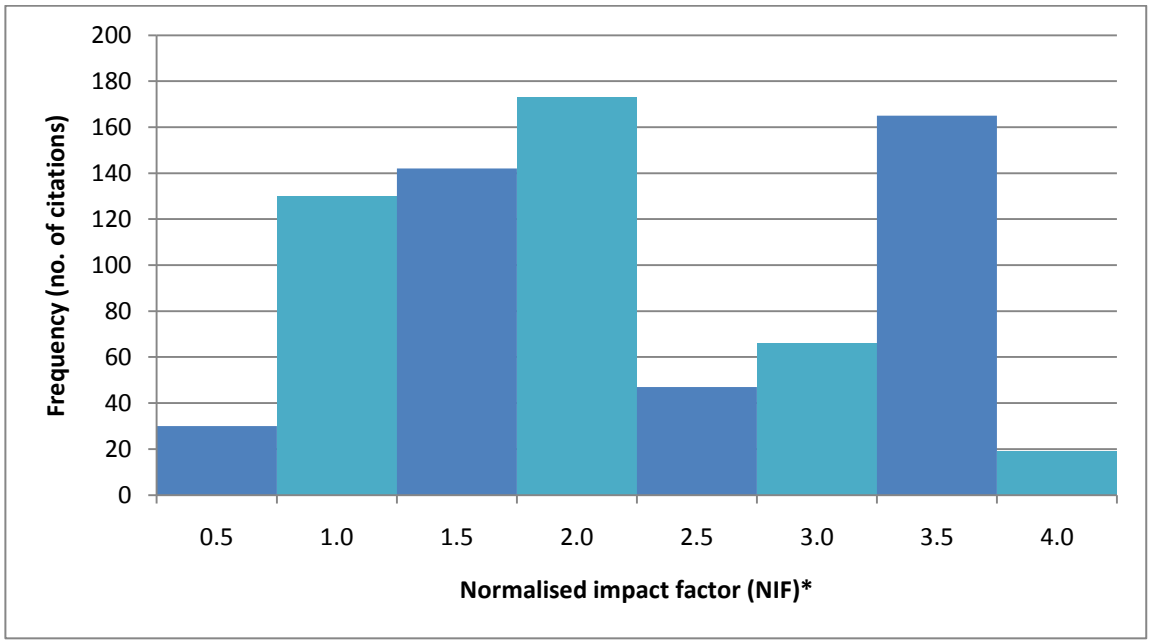
4.4.3 Comparing impact factor distributions for citing journals

Figure 5: *Distribution of NIF values for full exports from LIS journals*



*NIF axis labels signify upper limits of intervals so 0.5 is 0≤NIF<0.5, 1.0 is 0.5≤NIF<1, etc.
Data points not represented: 14,1; 21,1; 67.5,1

Figure 6: *Distribution of NIF values for full exports from non-LIS journals*

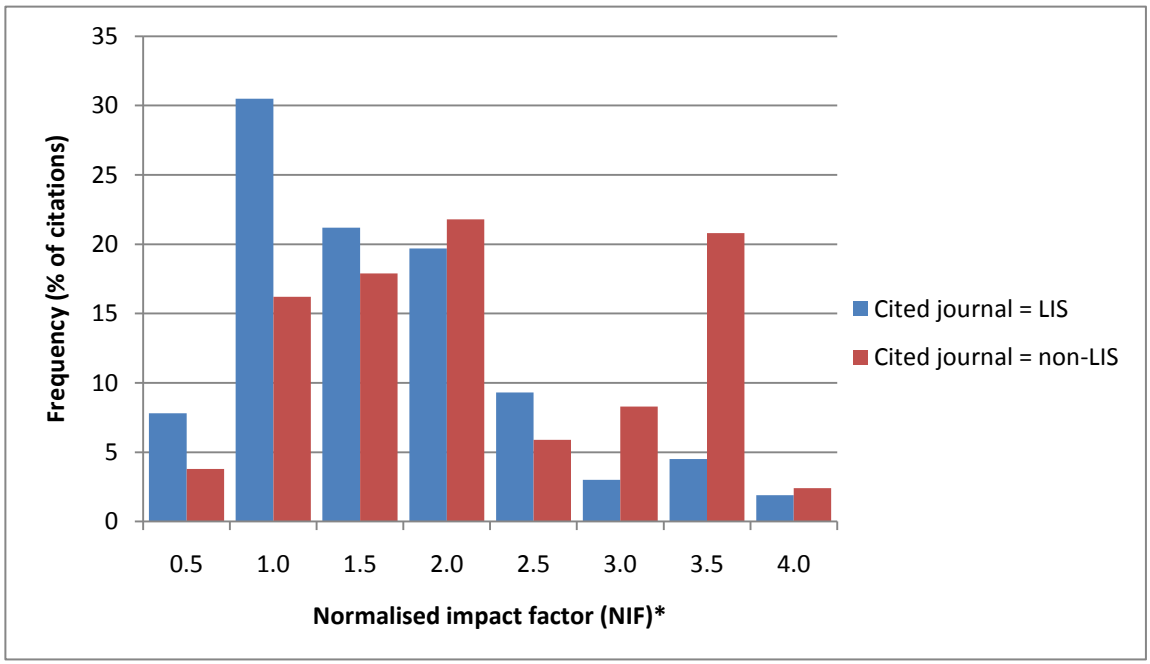


*NIF axis labels signify upper limits of intervals so 0.5 is 0≤NIF<0.5, 1.0 is 0.5≤NIF<1, etc.
Data points not represented: 4.5,1; 5,1; 5.5,2; 6.5,2; 8,2; 8.5,1; 9,1; 9.5,1; 11.5,2; 12,1; 14,2; 15,1; 21,1; 23.5,1; 30,1

There is a clear difference between the NIF distributions for exports from LIS journals and exports from non-LIS journals (see figures 5 and 6). For citations to LIS journals, NIFs range from 0.113 (*African Journal of Business* Management) to 67.161 (*Science*), with a median value of 1.230. The overall range is smaller for citations to non-LIS journals, 0.059 (*Neural Regeneration Research*) to 29.896 (*Lancet*), but the median is higher at 1.718. The LIS distribution peaks at the interval 0.5≤NIF<1 and then reduces fairly steadily with only six isolated citations occurring above a NIF of 4. Whilst the non-LIS distribution makes the same sudden jump from NIFs of less than 0.5 to NIFs of less than 1, the frequencies then continue to increase up to a peak at the interval 1.5≤NIF<2, and there are many more high-level NIFs.

However for both distributions the majority of citations are average or above average for their subject category (NIF≥1)- 61.7% for LIS journals and 79.8% for non-LIS journals. This trend is significantly more prominent for exports from non-LIS journals, though. Where LIS articles are published in LIS journals they are less consistently exported to high impact journals than when they are published in non-LIS journals. Therefore publishing in non-LIS journals not only results in LIS research being more widely cited outside of the field, but it also attracts higher status citing journals, increasing its potential influence and impact once cited. Figure 7 directly compares the two groups of citations with citation counts shown as percentages. Tables 11 and 12 show the individual journals with the highest CC x NIF scores for both groups of LIS articles.

***Figure 7**: Comparing NIF distributions for LIS and non-LIS cited journals (NIF<4)*



*NIF axis labels signify upper limits of intervals so 0.5 is 0≤NIF<0.5, 1.0 is 0.5≤NIF<1, etc.

***Table 11**: Top ranked citing journals by citation count x NIF (cited journal = LIS)*

Rank	Journal title*	CC	NIF	CC x NIF
1	SCIENCE	1	67.161	**67.161**
2	***PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA***	1	20.923	**20.923**
3	***COMPUTERS & EDUCATION***	6	3.047	**18.282**
4	EXPERT SYSTEMS WITH APPLICATIONS	8	1.819	**14.552**
5	PLOS MEDICINE	1	13.882	**13.882**
6	PLOS ONE	2	6.362	**12.724**
7	COMMUNICATIONS OF THE ACM	5	2.339	**11.695**
8	PUBLIC UNDERSTANDING OF SCIENCE	3	3.739	**11.217**
9	SCIENCE COMMUNICATION	5	2.075	**10.375**
10	INTERNATIONAL JOURNAL OF APPLIED EARTH OBSERVATION AND GEOINFORMATION	5	1.557	**7.785**
11	NEW MEDIA & SOCIETY	5	1.434	**7.170**
12	***REMOTE SENSING OF ENVIRONMENT***	2	3.584	**7.168**
13	COMPUTERS IN HUMAN BEHAVIOR	5	1.390	**6.950**
14	BRITISH JOURNAL OF EDUCATIONAL TECHNOLOGY	2	3.276	**6.552**
15	INTERNATIONAL JOURNAL OF NURSING STUDIES	3	2.159	**6.477**
16	INFORMATION RETRIEVAL	5	1.200	**6.000**
17	CURRENT SCIENCE	3	1.921	**5.763**
18	CYBERPSYCHOLOGY & BEHAVIOR	3	1.864	**5.592**
19	JOURNAL OF COMMUNICATION	2	2.662	**5.324**
20	PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A-MATHEMATICAL PHYSICAL AND ENGINEERING SCIENCES	1	5.261	**5.261**

*Those shown in ***bold italics*** feature in the ranking for both LIS and non-LIS cited journals

***Table 12**: Top ranked citing journals by citation count x NIF (cited journal = non-LIS)*

Rank	Journal title*	CC	NIF	CC x NIF
1	JOURNAL OF CHEMICAL INFORMATION AND MODELING	111	3.310	**367.410**
2	JOURNAL OF MEDICINAL CHEMISTRY	26	3.265	**84.890**
3	DRUG DISCOVERY TODAY	18	2.711	**48.798**
4	JOURNAL OF COMPUTER-AIDED MOLECULAR DESIGN	22	1.718	**37.796**
5	LANCET	1	29.896	**29.896**
6	CURRENT OPINION IN CHEMICAL BIOLOGY	8	3.401	**27.208**
7	COMBINATORIAL CHEMISTRY & HIGH THROUGHPUT SCREENING	16	1.563	**25.008**
8	CURRENT MEDICINAL CHEMISTRY	11	2.174	**23.914**
9	CHEMICAL SOCIETY REVIEWS	1	23.483	**23.483**
10	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	2	11.246	**22.492**
11	***PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA***	1	20.923	**20.923**
12	CURRENT TOPICS IN MEDICINAL CHEMISTRY	8	2.578	**20.624**
13	CURRENT OPINION IN DRUG DISCOVERY & DEVELOPMENT	10	1.902	**19.020**
14	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	2	7.967	**15.934**
15	USER MODELING AND USER-ADAPTED INTERACTION	6	2.579	**15.474**
16	***COMPUTERS & EDUCATION***	5	3.047	**15.235**
17	ANNALS OF INTERNAL MEDICINE	1	14.870	**14.870**
18	MINI-REVIEWS IN MEDICINAL CHEMISTRY	9	1.644	**14.796**
19	PATIENT EDUCATION AND COUNSELING	6	2.463	**14.778**
20	***REMOTE SENSING OF ENVIRONMENT***	4	3.584	**14.336**

*Those shown in ***bold italics*** feature in the ranking for both LIS and non-LIS cited journals

5 Conclusions

5.1 Key findings

Citations searches produced a body of 1061 non-LIS articles citing exports from LIS. These articles represent 444 unique journal titles with well over half of the journals making only one citation.

The journals and subject areas citing the most are determined to a significant extent by bulk citations to individual LIS articles, authors or institutions. In particular, a dominance of chemistry-related subjects is present due to extensive citations to Sheffield's chemoinformatics research. This suggests that LIS research relating to scientific information is particularly influential outside of the field. Although overshadowed, other journals and subject areas are present amongst the highest citers. Computer Science, Interdisciplinary Applications is the highest citing subject category. Key social sciences influenced by LIS include education, management and communication. From these citation count trends it can be concluded that LIS export performance is dependent on the exact nature of the original LIS research, and that export channels are potentially strongest where journals cite widely within LIS.

Normalised IFs for the citing journals indicate that 75.2% of citations are from journals with an above average impact for their subject category. This suggests that LIS is having a significant impact outside of the field. The shape of the NIF distribution illustrates a peak in frequency at the surprisingly high NIF interval of $1.5 \leq NIF < 2$. From this it can be inferred that LIS is making many high value exports. Some exceptionally high NIFs are present amongst the citing journals, predominantly from isolated single or double citations from chemistry- or medical-related journals. Taking into account both citation counts and NIFs, *Computers and Education* emerges as a particularly

prominent importing journal from the social sciences due to its high citation count, high NIF, and citations to a range of LIS institutions, authors and articles.

However the trends present can be accounted for to an extent by some crucial differences between exports from LIS articles published in LIS journals, and exports from LIS articles published in non-LIS journals. Firstly, it was found that LIS articles in non-LIS journals tend to attract higher numbers of citations from outside the field. Secondly, the subject destinations of the two groups of exports are quite distinct. Some high citing subject areas, for example computer science, are shared. But the identified dominance of chemistry and medical subjects is limited to the non-LIS group, with the citations to LIS journals covering more social sciences. Thirdly, and most importantly, the NIF distributions for the two groups of citations are significantly different. Whereas 61.7% of the citations to LIS journals have an average or above average NIF, this value increases to 79.8% for citations to non-LIS journals.

This leads to the conclusion that LIS research is more likely to be exported to high impact journals, and have a wider external influence, when articles are initially published in non-LIS journals. This has two main implications. In terms of LIS scholarship it suggests that academics can potentially maximise the influence of their research on external disciplines by exporting pre-publication and publishing in a non-LIS journal. In terms of import-export methodologies it suggests that export patterns are determined more by the exporting journal than the exporting author.

5.2 Meeting the aim and objectives

The overall aim of the study was 'to investigate the influence of LIS exports and the extent to which import-export studies in LIS can be enhanced by incorporating the measure of journal impact factor'. The objectives making up this aim were fulfilled as follows:

Objective 1: To carry out a literature review providing a contextual background for the themes of the import and export of ideas through citations, and the use of impact factors in citation analysis.

Section 2 of the study comprises an extensive literature review on the topics of citation analysis, import-export, and the application of impact factors.

Objective 2: To identify a body of papers citing high quality LIS research.

High quality LIS research was obtained by using a subset of the LIS submissions to the 2008 Research Assessment Exercise. Citations to these articles were accessed by carrying out searches in Web of Science Cited Reference Search. A limitation of the LIS research used is that it means the results of the study may not be representative of the field as a whole.

Objective 3: To analyse non-LIS citations to LIS research in terms of the numbers of citations and the impact factors of the citing journals.

Non-LIS citations were identified by examining the subject categories assigned to citing journals. Impact factors were obtained for the non-LIS journals from Journal Citation Reports and normalised to take account of subject differences. Analyses were conducted by ranking citing journals by citation count and normalised impact factor (NIF), and plotting NIF distributions. A planned comparison of changes in the IFs of citing journals over time was not possible due to time constraints.

Objective 4: To assess the influence of LIS on external disciplines as indicated by citation counts and journal impact factors.

By looking at the citation counts, impact factors, and subject categorisations of importing journals, it was possible to describe and quantify LIS's influence. Normalised impact factors provided a measure of whether exports were high or low value and this was equated with LIS's level of influence on particular journals and disciplines.

Objective 5: To evaluate the application of journal impact factor in import-export studies.

An effective means of normalising IFs was devised and implemented. These normalised values were successfully used to quantifying the value of exports from LIS. NIF distributions feature some particularly high values. This emphasises the need to contextualise NIFs by following up export connections and assessing what kind of LIS research is generating high status citers. To increase the level of balance when quantifying the value of exports NIFs were multiplied by citation counts. However for this measure to be most accurate a normalised form of citation count would also perhaps be necessary.

Supplementary objectives

As the study progressed it became clear that a central issue was whether or not there was any difference between exports from LIS journals and exports from non-LIS journals. This question was answered by analysing citations to the two groups of LIS articles separately. A key outcome of this was to highlight how using author affiliation to assign disciplinarity in import-export studies can be misleading.

5.3 Recommendations for further research

- Extend the LIS sample to see if similar export themes are present across a wider body of LIS research.
- Carry out a similar study using LIS papers from the 2001 Research Assessment Exercise to identify any changes in how high quality LIS research has been exported over time.
- Further investigate how the range of distinct LIS articles, authors, institutions and journals cited by a non-LIS publication can be combined with impact factors as an added quantification of import-export performance.
- Investigate and compare export performances across the range of non-LIS journals that LIS articles are published in. The present study has shown a

difference in the quality of exports depending on whether or not LIS research is published in an LIS journal. It would be interesting to develop this preliminary finding and see if particular non-LIS journals make LIS research more attractive to high impact journals.

- Compare impact factors of journals publishing LIS research with impact factors of journals from other disciplines which are importing this research to see if there is any correlation between the two.

Total word count: 15,256

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Appendix- sample pages from spreadsheets

Citing journals (full exports)

WoS subject category	Publication name	Citation count	IF	NIF
Computer Science, Cybernetics; Computer Science, Information	ACM TRANSACTIONS ON COMPUTER-HUMAN INTERACTIC	1	1.833	**1.610**
Computer Science, Information Systems; Computer Science, Sof	ACM TRANSACTIONS ON DATABASE SYSTEMS	1	1.216	**1.163**
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	5	1.085	**0.995**
Computer Science, Information Systems; Computer Science, Sof	ACM TRANSACTIONS ON THE WEB	1	1.909	**1.826**
Biochemical Research Methods; Biochemistry & Molecular Biol	ACTA CRYSTALLOGRAPHICA SECTION D-BIOLOGICAL CRYS	1	6.326	**2.788**
Medicine, General & Internal	ACTA MEDICA PORTUGUESA	1	0.256	**0.228**
Chemistry, Multidisciplinary	ACTUALITE CHIMIQUE	2	0.145	**0.128**
Computer Science, Artificial Intelligence; Engineering, Multidisci	ADVANCED ENGINEERING INFORMATICS	1	1.400	**1.532**
Chemistry, Multidisciplinary; Chemistry, Physical; Nanoscience &	ADVANCED MATERIALS	1	10.857	**8.661**
Computer Science, Artificial Intelligence; Engineering, Electrical	ADVANCES IN ELECTRICAL AND COMPUTER ENGINEERING	1	0.688	**0.611**
Water Resources	ADVANCES IN WATER RESOURCES	1	2.470	**2.324**
Business; Management	AFRICAN JOURNAL OF BUSINESS MANAGEMENT	3	0.146	**0.113**
Geriatrics & Gerontology	AGE AND AGEING	2	2.719	**1.307**
Gerontology	AGEING & SOCIETY	2	1.309	**1.087**
Computer Science, Artificial Intelligence	AI COMMUNICATIONS	1	0.837	**0.617**
Computer Science, Software Engineering; Mathematics, Applied	ALGORITHMICA	1	1.239	**1.414**
Biochemical Research Methods; Biotechnology & Applied Micro	ALGORITHMS FOR MOLECULAR BIOLOGY	1	2.800	**1.435**
Psychology, Clinical; Social Sciences, Interdisciplinary	AMERICAN BEHAVIORAL SCIENTIST	1	0.492	**0.543**
Gastroenterology & Hepatology	AMERICAN JOURNAL OF GASTROENTEROLOGY	1	6.882	**3.072**
Health Care Sciences & Services	AMERICAN JOURNAL OF MEDICAL QUALITY	1	1.707	**1.004**
Psychology, Multidisciplinary	AMERICAN JOURNAL OF PSYCHOLOGY	1	0.582	**0.546**
Anesthesiology	ANAESTHESIST	1	0.729	**0.335**
Chemistry, Analytical	ANALYST	1	3.913	**2.162**
Chemistry, Analytical	ANALYTICA CHIMICA ACTA	1	4.310	**2.381**
Chemistry, Multidisciplinary	ANGEWANDTE CHEMIE-INTERNATIONAL EDITION	2	12.730	**11.246**
Physics, Multidisciplinary	ANNALEN DER PHYSIK	2	0.861	**0.901**
Telecommunications	ANNALES DES TELECOMMUNICATIONS-ANNALS OF TELEC	1	0.602	**0.741**
Medicine, General & Internal	ANNALS OF FAMILY MEDICINE	1	4.457	**3.962**

Citing articles (full exports)

WoS subject category	Publication name	IF	NIF	Cited author	Institution	Cited journal
Computer Science, Cybernetics; Computer Sc	ACM TRANSACTIONS ON COMPUTER-HUMAN INTERACTION	1.833	**1.610**	Foster 3	Aberystwyth	LIS
Computer Science, Information Systems; Con	ACM TRANSACTIONS ON DATABASE SYSTEMS	1.216	**1.163**	Willett 3	Sheffield	x
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	1.085	**0.995**	Robertson 2	City	x
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	1.085	**0.995**	Whittaker 3	Sheffield	x
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	1.085	**0.995**	Whittaker 3	Sheffield	x
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	1.085	**0.995**	Whittaker 3	Sheffield	x
Computer Science, Information Systems	ACM TRANSACTIONS ON INFORMATION SYSTEMS	1.085	**0.995**	Willett 3	Sheffield	x
Computer Science, Information Systems; Con	ACM TRANSACTIONS ON THE WEB	1.909	**1.826**	Nicholas 3	UCL	LIS
Biochemical Research Methods; Biochemistry	ACTA CRYSTALLOGRAPHICA SECTION D-BIOLOGICAL CRYSTALLO	6.326	**2.788**	Gillet 4	Sheffield	x
Medicine, General & Internal	ACTA MEDICA PORTUGUESA	0.256	**0.228**	Henwood 1	Brighton	x
Chemistry, Multidisciplinary	ACTUALITE CHIMIQUE	0.145	**0.128**	Willett 1	Sheffield	x
Chemistry, Multidisciplinary	ACTUALITE CHIMIQUE	0.145	**0.128**	Willett 4	Sheffield	x
Computer Science, Artificial Intelligence; Engi	ADVANCED ENGINEERING INFORMATICS	1.400	**1.532**	Enser 1	Brighton	LIS
Chemistry, Multidisciplinary; Chemistry, Physi	ADVANCED MATERIALS	10.857	**8.661**	Gillet 1	Sheffield	x
Computer Science, Artificial Intelligence; Engi	ADVANCES IN ELECTRICAL AND COMPUTER ENGINEERING	0.688	**0.611**	Nunes 1	Sheffield	LIS
Water Resources	ADVANCES IN WATER RESOURCES	2.470	**2.324**	Wood 2	City	x
Business; Management	AFRICAN JOURNAL OF BUSINESS MANAGEMENT	0.146	**0.113**	Lin 1	Sheffield	LIS
Business; Management	AFRICAN JOURNAL OF BUSINESS MANAGEMENT	0.146	**0.113**	Nunes 1	Sheffield	LIS
Business; Management	AFRICAN JOURNAL OF BUSINESS MANAGEMENT	0.146	**0.113**	Nunes 1	Sheffield	LIS
Geriatrics & Gerontology	AGE AND AGEING	2.719	**1.307**	Bath 1	Sheffield	x
Geriatrics & Gerontology	AGE AND AGEING	2.719	**1.307**	Bath 4	Sheffield	x
Gerontology	AGEING & SOCIETY	1.309	**1.087**	Bath 1	Sheffield	x
Gerontology	AGEING & SOCIETY	1.309	**1.087**	Bath 4	Sheffield	x
Computer Science, Artificial Intelligence	AI COMMUNICATIONS	0.837	**0.617**	Petrelli 1	Sheffield	x
Computer Science, Software Engineering; Ma	ALGORITHMICA	1.239	**1.414**	Clough 1	Sheffield	x
Biochemical Research Methods; Biotechnolo	ALGORITHMS FOR MOLECULAR BIOLOGY	2.800	**1.435**	Gillet 4	Sheffield	x
Psychology, Clinical; Social Sciences, Interdisc	AMERICAN BEHAVIORAL SCIENTIST	0.492	**0.543**	Rowlands 3	UCL	LIS
Gastroenterology & Hepatology	AMERICAN JOURNAL OF GASTROENTEROLOGY	6.882	**3.072**	Booth 1	Sheffield	x

LIS research sample

Institution	Author	Title	Journal	Year	Vol. (no.)	pp.	Citations
Aberystwyth	Broady-Preston, J.E	Employees, customers and internal marketing str	Library Management	2002	23 (8/9)	384-393	x
Aberystwyth	Broady-Preston, J.E	Building better customer relationships: case stud	Library Management	2006	27 (6/7)	430-445	x
Aberystwyth	Ellis, D.P.	Information seeking and mediated searching. Par	Journal of the American Society for Information Science and	2002	53 (9)	695-703	34
Aberystwyth	Ellis, D.P.	Information seeking and mediated searching Part	Journal of the American Society for Information Science and	2002	53 (9)	728-735	28
Aberystwyth	Ellis, D.P.	Information seeking and mediated searching. Par	Journal of the American Society for Information Science and	2002	53 (11)	883-893	20
Aberystwyth	Eyre, G.D.	Back to basics:The role of reading in preparing yo	Reference Services Review	2003	31 (3)	219-226	x
Aberystwyth	Eyre, G.D.	Towards a literate Australia: the role of public lib	Australasian Public Libraries and Information Services	2004	17 (4)	186-192	x
Aberystwyth	Eyre, G.D.	What makes provision of e-learning successful? (	Education for Information	2005	23 (1/2)	43-55	x
Aberystwyth	Foster, A.E.	Information seeking and mediated searching. Par	Journal of the American Society for Information Science and	2002	53 (9)	704-715	43
Aberystwyth	Foster, A.E.	Information seeking and mediated searching stud	Journal of the American Society for Information Science and	2002	53 (9)	716-727	29
Aberystwyth	Foster, A.E.	Serendipity and information seeking: an empirica	Journal of Documentation	2003	59 (3)	321-340	49
Aberystwyth	Foster, A.E.	A nonlinear model of information seeking behavi	Journal of the American Society for Information Science and	2004	55 (3)	228-237	32
Aberystwyth	Hill, J.A.	Archive-text: an interdisciplinary dialogue	English Language Notes	2007	45 (1)	21-31	0
Aberystwyth	Horton, S.J.	Social capital, government policy and public valu	Aslib Proceedings	2006	58 (6)	502-512	0
Aberystwyth	Lonsdale, R.E.	Virtually there: e-books in UK academic libraries	Program	2002	36 (4)	216-227	x
Aberystwyth	Lonsdale, R.E.	The JISC user behaviour monitoring and evaluatic	Journal of Documentation	2004	60 (3)	302-320	13
Aberystwyth	Lonsdale, R.E.	Challenges in managing e-books collections in UK	Library Collections, Acquisitions, and Technical Services	2005	29 (1)	33-50	5
Aberystwyth	Lonsdale, R.E.	The role of the university library in supporting inf	Aslib Proceedings	2006	58 (6)	553-569	0
Aberystwyth	Preston, H.J.	Discovering the information professional: organi:	Online Information Review	2001	25 (6)	388-396	1
Aberystwyth	Preston, H.J.	Redesigning health administration for the medica	Health Informatics Journal	2003	9 (1)	33-37	x
Aberystwyth	Rafferty, P.M.	The representation of knowledge in library classi	Knowledge Organisation	2001	28 (4)	180-192	3
Aberystwyth	Rafferty, P.M.	Flickr and democratic indexing: dialogic approach	Aslib Proceedings	2007	59 (4/5)	397-410	13
Aberystwyth	Rafferty, P.M.	Constructing an image indexing template for the	Journal of Documentation	2007	63 (6)	898-919	1
Aberystwyth	Simon, A.M.	Women's perceptions of technological change in	Aslib Proceedings	2006	58 (6)	476-487	3
Aberystwyth	Tedd, L.A.	Reader development and ICT: an overview of prc	Journal of Librarianship and Information Science	2004	36 (4)	159-174	0
Aberystwyth	Tedd, L.A.	E-books in academic libraries: an international ov	New Review of Academic Librarianship	2005	11 (1)	57-79	x
Aberystwyth	Tedd, L.A.	Use and non-use of electronic information sourc	Online Information Review	2006	30 (1)	24-42	2
Aberystwyth	Tedd, L.A.	Use of library and information science journals b	Aslib Proceedings	2006	58 (6)	570-581	0