Survey of intellectual structure of the supply chain management in the past two decades

A citation and social network analysis

Arthur Morgan

Faculty of Business, University of Gloucestershire, Gloucester, UK

Abstract

Purpose – This paper aims to explore the way that the intellectual structure of the SCM discipline has been shaped over the last 20 years. The discipline is represented by the papers that are published in a network of ten leading academic journals in the field. As the SCM literature has grown, the analysis of the way that the characteristics of this network of journals have changed over time enables the identification of salient challenges facing SCM theory and practice for the new decade.

Design/methodology/approach – A combination of social network and citation analyses among the selected journals is applied. Citations between and within journals are collected and analysed using social network analysis metrics, that assess the communication patterns between and among the journals, the cohesion of the network and the role that each of the journals has performed (and is acquiring) in the dissemination of knowledge.

Findings – The analysis reveals that the current structure of the network of journals is characterised by an evident shift of focus of operations management journals towards more SCM phenomena, the cohesion of the discipline has improved but is still fragmented due to a lack of reciprocal co-citations among the journals, and the emergence of three distinctive clusters in the network.

Research limitations/implications – The study reflects the growth of supply chain management, by studying an eclectic number of academic journals over the past 20 years, but can be extended beyond this period and it can include more academic and practitioner journals to examine its extended problem domain.

Practical implications – The study confirms the inter-disciplinary nature of supply chain phenomena and the opportunity for research in SCM to acquire a central role in the study of inter-organisational systems.

Originality/value – Bibliographic studies have been conducted in the past in several (more established) disciplines. The study of where knowledge is communicated with co-citations among papers and journals provides concrete evidence of the changing characteristics of an academic discipline. The SCM discipline is maturing as an academic discipline and the analysis of its intellectual structure can assist in establishing its legitimacy and future expansion.

Keywords Supply chain management, Social network analysis, Citation analysis, Bibliometric study, Journals

Paper type Research paper

Introduction

Academic disciplines in social sciences emerge because there is the need to satisfy the demand for new knowledge that is necessary to explain phenomena created by the ever-changing political, demographic, economic and technological conditions and because individuals and organisations are interested in funding and doing research to
explain these phenomena (Berry and Parasuraman, 1993; Heineke and Davis, 2007). Collaborations and networks then develop in conferences and through published works in journals and the field gradually takes shape.

As an academic field Supply Chain Management (SCM) evolved from the Operations Management Discipline (Harland, 1996). Supply chains always existed in industries, but the term SCM has been introduced in 1980s as a consulting solution to logistics management and its growth in business circles as a new competitive way of forming companies’ strategy and in academia as a new field of study has been reported extensively. This growth was a natural evolution which occurred to fill the academic gap of the externalisation of Operations Management, which was driven by the rapid changes in Information Technology that enabled more effective communication between business and the new competitive globalised environment created by economic, demographic and political developments that brought about the emergence of new forms of inter-organisational relationships (alliances, partnerships) (Giannakis and Croom, 2004).

The nature of SCM research has been examined by several scholars (See for example, Harland, 1996; Cooper et al., 1997; Fine, 2000; Croom et al., 2000; Tan, 2001; Chen and Paulraj, 2004; Lawson et al., 2006). It has been described as a multivariate discipline encompassing a large number of different literatures and research areas, spanning from Operations Management, Strategy and Marketing to Sociology and Geography (Giannakis and Croom, 2004), but has been criticised that it lacks clear theoretical and conceptual schema which define its boundaries (Chen and Paulraj, 2004), and that it overlaps with other competing disciplines like Operational Research and Marketing (Ganeshan et al., 1999; Lummus and Vokura, 1999; Lambert and Cooper, 2000; Croom et al., 2000).

The SCM field has been expanded over the past 30 years and continues to grow. Many pioneering scholars are still conducting research in the field and an increasing number of UG and PG programmes in SCM are developed and offered in universities around the world. There is a substantial growth of papers that refer to supply chain management phenomena or include the term supply chain in their title. Earlier works (Tan, 2001, Miles and Snow, 2007) examined the stages through which the SCM literature developed by analysing the different contributions to the development of SCM thought. Each of these contributions introduced a new feature to the totality of SCM thought.

The research presented in this paper investigates the way in which the academic field of SCM has evolved over time, not through an extensive critical analysis of the literature, but by analysing a network of eminent journals of the discipline. In order to better understand the changing characteristics of the SCM discipline, the citations that are exchanged between and among these journals are analysed. These citations represent the communication patterns between researchers and facilitate the dissemination of ideas between and within journals.

By studying and analysing how knowledge has been disseminated in the SCM literature, useful insights will be generated regarding the theory and practice of SCM, the identification of its problem domain and its inter-disciplinary nature as well as helping researchers to identify emerging themes. Traditionally, this can be done through an examination of a large number of contemporary literatures. The bibliometric study that this paper adopts does not analyse the pertinent literature of
SCM per se, but the way journals exchange knowledge (in the form of citations). This approach can also provide a clear picture of how the academic field of SCM has evolved but it also gives the opportunity to identify the role that each journal performs and how various streams of research can be combined to face future challenges of SCM phenomena. The study also gives the opportunity to identify the linkages of SCM with other disciplines to investigate if the existence of SCM fulfils a purpose, or performs a role for academics and practitioners. In this direction this paper addresses the following research objectives:

**RO1.** To identify a network of journals that can represent effectively the academic network of SCM discipline.

**RO2.** To collect the number of citations that appear in the published articles of these journals over a period of 20 years.

**RO3.** To identify the connections between journals, and identify the role that they play in the creation and dissemination of knowledge.

**RO4.** To identify how the field has changed over the past 20 years through the role of the journals in the network and point out agendas for future research in SCM.

The remainder of the paper is organised in five sections: In the first section, the two research methods that are utilised in this research (citation analysis and social network analysis) are introduced. The analytical steps that have been followed for the selection of the journals to be studied and the data collection procedure are outlined in the second section. The findings of the analysis are presented in the third section and a critical examination of the results in the fourth section. Finally in the last section potential extension of the research in the interested field is discussed.

**Citation and social network analyses**

**Citation analysis**

Published work in academic journals plays a critical role in the way that an academic discipline evolves. In their research, social scientists induce ideas by observing phenomena and also by reading articles that they find interesting and aid them in their thinking, which they cite in their work as an acknowledgement of debt to prior research. The knowledge that they then generate by applying those ideas in particular contexts with the use of analytical methods and established theories, is disseminated through the published works to other researchers from the same or different disciplines and more importantly to practitioners that use this it in their business practices. The analysis of connections between and within journals (i.e. the citations) can be seen therefore as a concrete evidence of where knowledge is generated and used (Garfield, 1979).

A citation is defined as ‘when one document (A) mentions or refers to another document (B), known as the source document. Citation Analysis has been used extensively to investigate the structure of many social sciences disciplines and natural sciences (Garfield, 1979). It may provide information on the identity of journals which make and receive citations (“directional” data) as well as information on the total number citations those journals make or receive (“valued” or “strength” data). At a micro level analysis it could provide greater information about the citations made and
received from journals, authors, books, etc. The unit of analysis is the citations or references “any source like a journal article, a book, a working paper, or an unpublished dissertation, listed by the authors of the papers analysed” (Garfield, 1979).

Social network analysis
The flows of communication and exchanges of ideas through citations can be further understood by complementing the citation analysis with the Social Network Analysis (SNA) technique. A Social Network consists of a finite set of social actors and the relations defined on them (Wasserman and Faust, 1994). SNA is a method that investigates the relationships between the social actors through analysis of the structure of the social network, with the use of relational data (Scott, 2006). These are the contacts, ties, or information that is exchanged between actors, which relate one actor to another. The measures of the relationships could include influence, affinity, patterns of communication, or the cohesion between the actors (Wasserman and Faust, 1994).

With this technique a network of actors is defined as individuals within an organisation, organisations within a supply chain, or in the case of a citation analysis, the academic journals within a scholarly discipline. In the case of the network of academic journals, SNA could be utilised to better understand the relationships between and among its actors (journals), by studying the information that is exchanged between and among the members (citation data) and provide insights into how knowledge is spread throughout the academic community.

The Citation Analysis can be therefore combined with the SNA in order to understand the characteristics of the network, by describing how communication patterns between and among journals have shaped it. With the combination of SNA and citation analysis information can be drawn on how SCM as an academic discipline has evolved over the past 20 years, to what extent it reached maturity and how its future will be shaped by the generation of new knowledge through the interaction of the members of its intellectual network (journals).

Research design and data collection
Journal selection
The goal of the study is to include journals that are important in the broad field of SCM. For that reason a “positional approach” in the use of the SNA was followed. A large number of journals that have extensively published works related to SCM were identified first. Previous works that investigated the SCM problem domain were visited (Philips and Philips, 1998; Carter et al., 2007) and the journals that they included in their study were added to those that were found in extensive literature reviews (Croom et al., 2000, Tan, 2001). An initial list of 35 journals was produced which arguably covers a thorough (but not exhaustive) spectrum of the SCM field. Global databases of academic and practitioner journals like ABI/INFORM, Business Source Premier and EBSCO were also consulted in order to select the journals. Table I outlines the initial selection of the journals that are considered to be relevant to SCM.

The final selection of the journals that were included in the analysis was made after a filtering of four steps.

1. The journals that do not use refereed publications were not included.
2. The journals that refer solely to practitioners were not included.
Journals that appear on the Association of Business Schools Journal Quality Guide of 2010 were included (Harvey et al., 2010) (3) Only the journals that specialise in SCM phenomena were included. This process enabled a thorough investigation of the expanding SCM problem domain. For the purposes of conducting a reliable analysis and to avoid bias in the collected data, which could have probably skewed the results, the study focused on those journals that have clear theoretical orientation towards SCM issues. Journals that stem from the Operational Research Discipline were excluded (i.e. The Journal of Operational Research Society, European Journal of Operational Research) as well as journals that have fragmentally published papers in SCM, or a few issues related to SCM (i.e. the International Journal of Production Economics, International Journal of Production Research and Industrial Marketing Management), despite the fact that they may be important actors in generating and disseminating knowledge in their field.

After the filtering process the journals that were selected are outlined in Table II. It is always very difficult to draw the boundaries of a social network, as this entails the problem of leaving out actors/journals that could influence its behaviour. The main objective of this paper however is to see how the SCM discipline has evolved over time and not to compile a normative and comprehensive list of journals that define its boundaries. These boundaries have changed (and are likely to change) and the inclusion of all the journals that are currently publishing papers related to SCM would
not satisfy the main objective of the study. The selected journals are well known and established academic journals in the field of SCM.

Data collection
The main sources of collecting citation data are the Social Science Citation Index and the Journal Citation Reports that come out every year, as well as an online database, Google scholar (http://scholar.google.com). These sources however do not cover some of the journals under investigation, mainly because they are comparatively new and/or have been criticised of having limitations and reliability problems (Reed, 1995). Google scholar has also been criticised for errors that include missing data and discrepancies between citing and cited data (Falagas et al., 2008). For these reasons citations were collected manually from the journals themselves. All the citations that have been used in all the papers that have been published in the journals of the selected network were collected (using online bibliographic databases such as Business Source Premier, Proquest and Science Direct). Then the number of citations in each of the ten journals was manually counted and the number of times each journal cited the others and itself was calculated. For example, the number of times that papers which were published in a particular journal appear as citations in papers that were published in another journal was calculated. The collected citation data were then used to construct directional valued $10 \times 10$ matrices, to investigate the relationship between journals through the calculation of specific SNA metrics.

Matrices construction
Matrices were constructed for each of the last 20 years 1991-2010 (see Table AI, Appendix 1). The figures in the matrices represent the number of times each journal cited the other journals, as well as the total annual number of citations within each journal. These yearly matrices were then summed up to create four five-year period matrices (1991-1995, 1996-2000, 2001-2004, 2006-2010) and then summed up again to create two ten-year period matrices (1991-2000 and 2001-2010). These combined matrices were used to smooth out any variances in a year, representing thus a better picture of sending and receiving citations between journals. They also facilitated the

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|}
\hline
Journal Name & Abbreviation & ABS Rank \\
\hline
Journal of Supply Chain Management & JSCM & 1 \\
Journal of Purchasing and Supply Management & JPSM & 2 \\
Supply Chain Management: An International Journal & SCMIJ & 3 \\
Journal of Operations Management & JOM & 4 \\
International Journal of Operations and Production Management & IJOPM & 3 \\
International Journal of Logistics Management & IJLM & 2 \\
Journal of Business Logistics & JBL & 2 \\
International Journal of Physical Distribution and Logistics Management & IJPDLM & 2 \\
Journal of Enterprise Information Management & JEIM & 1 \\
Transportation Research, Part E: Logistics and Transportation Review & LTR & 3 \\
\hline
\end{tabular}
\caption{Network of academic journals studied}
\end{table}
comparison between the periods in terms of the structural characteristics of the network.

Some journals had a lot more citations than others because they publish more papers, or because their authors use more citations (e.g. the *JOM* compared to *LTR*). The data in these highly citing (and cited) Journals would overwhelm other data in the matrices and skew the relational characteristics of the network. A technique that is used to control this potential source of error is to normalise the data. For that purpose, the rows of the matrices were normalised to account for that fact. Row normalisation refers to changing the scale of numbers in the matrix when we wish the data matrix to have the same mean or standard deviation (Borgatti *et al.*, 2002; Scott, 2006). An eleventh column was added to each matrix including the sums of all the citations made by the network of the ten journals. The rows of the matrices were subsequently normalised using marginal normalisation (Borgatti *et al.*, 2002). By forcing the sum of the elements to be 100, the cell entries were linked to percentages of citations given or received, instead of the actual number of citations. All the analyses for the calculation of the relational indicators between the journals and the characteristics of the network were performed using the normalised $10 \times 10$ matrices, leaving the eleventh column out. This procedure resulted to the normalised matrices presented in Appendix 1. The matrices were analysed using the software UCINET 6.2 that handles relational data (Borgatti *et al.*, 2002).

**Data analysis**

*Social network analysis indicators*

The analysis of the matrices focused on three areas: the identification of the relationships between the selected journals, the formation of groupings or cliques among journals, the position of each journal in the network and the structure of the network. It also explored how these have changed over the past 20 years.

The relationships between the journals of the network, and the role that each journal plays in the network, have been identified by assessing, and analysing several SNA metrics. These metrics include the number of self-citations (the number of citations provided in a paper of one journal to other documents published by the same journal), the level of centrality of each journal (the level to which a particular journal receives citations from other journals), the level of betweenness (the degree to which a particular journal cites many journals and not just a few), and the level of closeness (how close is one journal to another through reciprocal co-citations as well as how close is a journal to all the other journals in the network).

For the identification of groupings/cliques in the network analysis, a hierarchical clustering analysis has been conducted to show how groupings of particular journals have formed over the 20-year period. The way that the intellectual field of SCM field evolved has been identified by conducting a multi-dimensional scaling analysis to map how the position of each journal in the network has changed over the past 20 years, and using hierarchical clustering to illustrate how relationships between journals have changed. In addition, the SNA measure of structural equivalence has been used to identify the position of a journal in the network.

The structure of the network has been identified through the assessment of the cohesion of the network (how dense is the network by looking at the degree of citations
made by the journals of the network to each other and not to other academic journals) and the position of each journal (the level of similarity between journals).

The results of the analysis in terms of the social network analysis indicators that have been used are discussed in the following.

**Descriptive analysis**
A correlation between the normalised matrices of the periods 1991-2000 and 2001-2010 was conducted first to reveal if any major differences took place in the network over the past 20 years. The overall correlation between the two matrices was 0.79, indicating that the overall citation network has been rather stable. Further, more refined analysis of differences between the periods, using the measures of centrality, betweenness, the position in the network and the cohesion of the network can reveal particular changes that have taken place.

**Roles and relationships between journals**

**Self-citations**
The use of self-citations by a journal implies that the journal is independent and does not exchange knowledge with the rest of the network. As it is illustrated in Appendix 1, the journals with the highest percentage of self-citations for the entire 20-year period are the *JOM* and *IJOPM*, followed by the *JSCM* and *IJPDLM*. As expected, newer journals such as the *JPSM* (was introduced in 1996) and *SCMIJ* (was introduced in 1997) did not cite themselves as much in the first decade. An analysis of the matrices also reveals that self-citations constitute most of the citations in the network of journals, and over the past 20 years there has been an increasing trend in the number of self-citations (but also an increased number of total citations), a fact that indicates that the whole network has become more self-contained.

**Centrality**
Centrality in a social network is a concept that illustrates the most important and prominent actors in the network (Wasserman and Faust, 1994). These actors possess a strategic location within the network. There are many ways of measuring the dimensions of prominence in a network. For the purposes of this study, the metrics of degree centrality, the betweenness and the closeness of the network are utilised using the Freeman approach (Borgatti *et al.*, 2002).

**Degree centrality**
The actors that are more central and prominent in the network of journals are the most active in terms of the number of citations they received from the other journals (their indegree) than the citations the make (their outdegree). As it can be seen in Table III the most prominent journal in terms of the citations received and made is the *JSCM* with a difference of 87.7 followed by the *JEIM* with a difference of 29.2 and the *IJPDLM* with a difference of 25.6. The two OM journals are relatively central to the network with high levels of outdegree and indegree. Substantial difference appears in the indegree of *JEIM* over the past ten years, making the journal a more prominent actor in the network. The network centralization (degree to which the entire network is focused around a few central nodes) has slightly increased over the last 20 years. This indicates a relative consolidation of the network around a few journals, a finding that can be
<table>
<thead>
<tr>
<th>Journal</th>
<th>1991-2000(^a)</th>
<th>2001-2010(^b)</th>
<th>1991-2010(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IJLM</td>
<td>OutDegree: 78.90 InDegree: 48.80 Difference: 30.1</td>
<td>OutDegree: 79.10 InDegree: 48.50 Difference: 30.6</td>
<td>OutDegree: 79.00 InDegree: 43.30 Difference: 35.7</td>
</tr>
<tr>
<td>IJOPM</td>
<td>OutDegree: 56.10 InDegree: 76.10 Difference: -20</td>
<td>OutDegree: 62.80 InDegree: 91.00 Difference: -28.2</td>
<td>OutDegree: 60.20 InDegree: 85.80 Difference: -25.6</td>
</tr>
<tr>
<td>IJPDLM</td>
<td>OutDegree: 64.00 InDegree: 150.30 Difference: -86.3</td>
<td>OutDegree: 67.40 InDegree: 87.50 Difference: -20.1</td>
<td>OutDegree: 65.70 InDegree: 81.90 Difference: -16.2</td>
</tr>
<tr>
<td>JBL</td>
<td>OutDegree: 51.10 InDegree: 96.30 Difference: -45.2</td>
<td>OutDegree: 70.00 InDegree: 66.30 Difference: 3.7</td>
<td>OutDegree: 62.50 InDegree: 80.30 Difference: -17.8</td>
</tr>
<tr>
<td>JOM</td>
<td>OutDegree: 47.20 InDegree: 52.50 Difference: -5.3</td>
<td>OutDegree: 62.60 InDegree: 97.80 Difference: -35.2</td>
<td>OutDegree: 58.60 InDegree: 85.20 Difference: -26.6</td>
</tr>
<tr>
<td>JSCM</td>
<td>OutDegree: 53.00 InDegree: 175.00 Difference: -122</td>
<td>OutDegree: 63.10 InDegree: 141.30 Difference: -78.2</td>
<td>OutDegree: 59.90 InDegree: 147.60 Difference: -87.7</td>
</tr>
<tr>
<td>JEIM</td>
<td>OutDegree: 42.00 InDegree: 31.60 Difference: 10.4</td>
<td>OutDegree: 44.80 InDegree: 62.60 Difference: -17.8</td>
<td>OutDegree: 50.60 InDegree: 79.72 Difference: -29.2</td>
</tr>
<tr>
<td>SCMIJ</td>
<td>OutDegree: 87.20 InDegree: 3.60 Difference: 83.6</td>
<td>OutDegree: 71.00 InDegree: 95.90 Difference: -24.9</td>
<td>OutDegree: 71.60 InDegree: 66.30 Difference: 5.3</td>
</tr>
<tr>
<td>LTR</td>
<td>OutDegree: 70.80 InDegree: 24.60 Difference: 46.2</td>
<td>OutDegree: 79.20 InDegree: 26.80 Difference: 52.4</td>
<td>OutDegree: 75.60 InDegree: 26.50 Difference: 49.1</td>
</tr>
</tbody>
</table>

Notes: \(^a\)Net Centralization (Outdegree) = 5.80 per cent; Net Centralization (Indegree) = 29.53 per cent; \(^b\)Net Centralization (Outdegree) = 6.13 per cent; Net Centralization (Indegree) = 31.74 per cent; \(^c\)Net Centralization (Outdegree) = 6.72 per cent; Net Centralization (Indegree) = 34.09 per cent
interpreted that the academic field of SCM is maturing and developing around the intellectual focus of the selected journals.

**Betweenness**
The concept of betweenness is another way to measure the prominence in a network and refers to the extent to which a particular point lies between the various other points in the graph: a point of a relative low degree may play an important intermediary role and so be very central to the network (Scott, 2006). Thus the journals that are “in between” may act as gatekeepers in the dissemination of knowledge among the network. The betweenness analysis was conducted to confirm and consolidate the results for degree centrality as well as to show which journals act as gatekeepers in the dissemination of knowledge in the network.

The relative difference that exist in the scores of the journals (see Table IV) indicate the more or less betweenness of the journals (highest score means higher level of betweenness). Over the past 20 years the more central journals in the sense that they were located between many other Journals were the *JSCM, JOM* and the *JBL*. The SMIJ and *JEIM* underwent a remarkable increase in terms of their betweenness (their are is ranked third and fourth for 2001-2010 respectively), acquiring a prominent liaison in the exchange of citations. Overall, the journal “most between” other journals was the *JSCM*. By comparing the two-decade periods, the 2001-2010 decade is characterised by the emergence of a fewer centrally located journals that channel the information/knowledge in the network.

**Closeness**
Opposite to degree centrality that shows the “local centrality” (i.e. the centrality in the immediate environment of the journal), the level of closeness indicates how “globally central” a journal is. This measure focuses on how close an actor is to all the other actors in the network (Wasserman and Faust, 1994) and expresses the global centrality of a network, i.e. a journal would be globally central if it lies at short geodesic distances from many other journals (nodes of the network). Journals with high level of closeness centrality therefore, could be very productive in disseminating knowledge to other journals in the network. As it can be seen in the results if analysis of matrices for the

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JPSM</strong></td>
<td>4.93</td>
<td>5.21</td>
<td>5.11</td>
</tr>
<tr>
<td><strong>IJLM</strong></td>
<td>7.88</td>
<td>4.47</td>
<td>5.74</td>
</tr>
<tr>
<td><strong>IOPM</strong></td>
<td>18.64</td>
<td>8.80</td>
<td>10.22</td>
</tr>
<tr>
<td><strong>IFPDL</strong></td>
<td>12.35</td>
<td>6.38</td>
<td>7.80</td>
</tr>
<tr>
<td><strong>JBL</strong></td>
<td>6.74</td>
<td>5.57</td>
<td>5.98</td>
</tr>
<tr>
<td><strong>JOM</strong></td>
<td>5.75</td>
<td>8.88</td>
<td>7.12</td>
</tr>
<tr>
<td><strong>JSCM</strong></td>
<td>8.74</td>
<td>15.46</td>
<td>11.26</td>
</tr>
<tr>
<td><strong>JEIM</strong></td>
<td>5.45</td>
<td>10.21</td>
<td>7.22</td>
</tr>
<tr>
<td><strong>SMIJ</strong></td>
<td>4.07</td>
<td>11.62</td>
<td>8.50</td>
</tr>
<tr>
<td><strong>LTR</strong></td>
<td>5.48</td>
<td>4.81</td>
<td>4.71</td>
</tr>
</tbody>
</table>

*Note: Network Centralization Index for 1991-2010 = 11.807 per cent*  

**Table IV.**
Longitudinal Betweenness of each journal
level of closeness of each journal, the most globally central journal for the 20 year period were the JSCM, the IJOPM and JOM and more recently the JEIM (see Table V).

In the analysis of the relationship between the journals in the network, each journal sends and receives citations from other journals. Those journals with the larger number of citations they receive, compared to the citations they make are perceived to be more central in the network. Centrality in the network is an indication of the prestige that a journal has. This prestige can be assessed by identifying the number of citations made, and received by each journal. Three measures were used in this study: degree betweenness and closeness. Those journals with high levels of indegree than outdegree and/or high betweenness scores are considered to possess prestige in the network, as they have been the most centrally positioned. The analysis over the past two decades revealed that while some journals played an important role in the first decade (e.g. IJPDLM), their role was lessened in the second decade. Conversely, the second decade saw the emergence of two new centrally positioned journals, JEIM and SCMIJ, along with the most prominent two journals for the entire period (JSCM and JOM).

**Groupings, cliques and structure of the network**
An analysis of the development of groupings and cliques was then conducted to identify if certain journals specialise and focus on specific themes/issues. Groupings of journals show that each member (journal) in a group will be directly linked to every other member in the same group. The technique of hierarchical clustering was utilised first to identify groups in the network.

**Hierarchical clustering**
This technique finds a series of nested partitions of the actors in a network. It groups journals into subsets, so that entities within a subgroup are relatively similar to each other (Wasserman and Faust, 1994). The different partitions are ordered according to decreasing levels of similarity. The algorithm begins with the identity partition (in which all items are in different clusters). It then joins the pair of items most similar (least different), which are then considered a single entity. The algorithm continues in this manner until all items are joined into a single cluster (the complete partition) (Borgatti et al., 2002). The similarities between journals are identified in terms of the way they cite (are cited) by other journals.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>InCloseness</td>
<td></td>
<td>OutCloseness</td>
<td></td>
<td>InCloseness</td>
<td></td>
</tr>
<tr>
<td>JPSM</td>
<td>60.00</td>
<td></td>
<td>75.00</td>
<td></td>
<td>75.00</td>
<td></td>
</tr>
<tr>
<td>IJLM</td>
<td>100.00</td>
<td></td>
<td>81.82</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>IJOPM</td>
<td>100.00</td>
<td></td>
<td>100.00</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>IJPDLM</td>
<td>100.00</td>
<td></td>
<td>90.00</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>JBL</td>
<td>90.00</td>
<td></td>
<td>75.00</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>JOM</td>
<td>90.00</td>
<td></td>
<td>69.23</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>JSCM</td>
<td>100.00</td>
<td></td>
<td>75.00</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>JEIM</td>
<td>64.28</td>
<td></td>
<td>90.00</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>SCMJJ</td>
<td>60.00</td>
<td></td>
<td>81.82</td>
<td></td>
<td>90.00</td>
<td></td>
</tr>
<tr>
<td>LTR</td>
<td>75.00</td>
<td></td>
<td>75.00</td>
<td></td>
<td>75.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1991-2010</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>InCloseness</td>
<td>75.00</td>
<td></td>
</tr>
<tr>
<td>OutCloseness</td>
<td>90.00</td>
<td></td>
</tr>
</tbody>
</table>

**Table V.**
Closeness

26,3
The output of the hierarchical clustering analysis is presented in the dendograms of Figures 1 and 2 and illustrates the groups of journals that are similar to each other in the two separate ten-year periods. The level of clustering refers to the degree of similarity among journals in the clusters. When comparing the two ten year periods, the cliques that emerge are quite different. For the first decade (1991-2000) the most central clique is composed by JEIM and IJLM in the first level. At the second level JBL,
and then the *JPSM* are added to the original clique forming a grouping, which is distinctive of the cliques of *JOM, IJOPM* and *IJPDLM* and *JSCM* that form another grouping after the second level. *SCMIJ* is added to the network in the third level. This analysis indicates that the network of the journals was fairly unorganised with several cliques being formed in the first level.

For the last ten-year period, the results present the formation of two distinct high-level clusters. On one side lie logistics oriented journals (*JEIM, IJLM, IJPDLM, JBL,* and *LTR*) and on the other side a cluster with the traditional OM journals is formed together with the newly formed SCM journals (*JPSM, JSCM, SCMIJ* and *JOM, IJOPM*). This finding indicates a more direct communication between the journals in the two distinctive cliques in period 2 than in period 1. *JEIM* has a central position in the network, being added to the logistics oriented grouping only at the second level. This indicates that *JEIM* is more interdisciplinary in its content when compared to journals that belong to a particular clique from level 1.

**Multi-dimensional scaling**

A Multidimensional Scaling (MDS) analysis was also performed to provide a visual depiction of the communication patterns among the journals of the network. Conceptually, the purpose of MDS is to provide a visual representation of the pattern of proximities (i.e. similarities or distances) among a set of objects. It can be interpreted to represent a two-dimensional recreation of the communication patterns between the journals in the network. For the journals that are close to one another on the map it means that they have stronger communication ties. Figure 3 illustrates the results of the metric MDS done by UCINET6 for the period 1991-2010. In Appendix 2 (see Figures A1, A2, A3, A4, A5 and A6), the MDS maps illustrate how the position of the journals has changed over the last 20 years, with the presentation of four consecutive five-year periods.

The MDS map shown previously indicates that for the period 1991-2010 three distinctive group of journals have been formed. On the right side the more logistics-oriented journals (*IJPDLM, JBL* and *IJLM*). More centrally in the network are

![Figure 3.](image-url)
the JSCM and SCMIJ with the JSCM very close to the centre. This could mean that this group (JSCM and SCMIJ) sends and receives citations from different sources in the network. The JEIM possesses a central role over the past five years, as it can be seen from the shift of its position in the map between 1991-2000 and 2001-2010. To the left side is the third group of the Operations Management related journals IJOPM and JOM.

The MDS maps in Appendix 2 demonstrate an interesting finding in the way that the network of journals has evolved over the past 20 years. It can be seen that the traditional OM journals are becoming more central in the network and form closer ties with the SCM journals. The position of the “logistics-oriented” journals (the IJPDL, JBL, IJLM, JEIM, and LTR) has changed as well. Three journals (IJPDL, IJLM and JEIM) have got closer to each other and the other journals. The LTR however has maintained peripheral position to the network, focusing mainly on transportation problems of SCM and on quantitative approaches to logistics. These changes show primarily signs of formation of a more cohesive network in the last decade (with the exception of the more quantitative logistics journals). This can be interpreted as an indication of a more established discipline of SCM.

Position in the network
The identification of the position in the network can identify the journals that are similar to one another and perform similar roles within the network. The measure of the structural equivalence has been utilised for this purpose. Structural equivalence illustrates whether some journals share the same role or perform the same function within a given network. Structurally equivalent journals occupy the same social network positions in that they have similar connections with the “other” journals (Doreian, 1985). The roles performed by these members can be many and varied. For example although two journals may not have strong ties in exchanging citations, they may both act as gatekeepers in their clusters. The CONCOR procedure of UCINET6 has been applied. This technique partitions the data by splitting blocks based on the convergence of iterated correlations of the actors/journals of the network, by performing a factor analysis on the correlations of the matrix. The equivalence characteristics of the network are shown in Appendix 3 (see Table AII), and the dendograms in Figures 4 and 5 exhibit the journals that perform similar roles in the network.

The analysis for the first period produces four groups of structurally equivalent journals: G1 (JSCM, IJLM, JPSM), G2 (SCMIJ, JEIM), G3 (JBL, IJPDL, LTR) and G4 (IJOPM, JOM). The analysis for the second decade also produced four structurally similar groups: G1 (JPSM, SCMIJ, JSCM), G2 (IJOPM, JOM), G3 (IJLM, JEIM) and G4 (IJPDL, JBL, LTR). For the second period the distinction between purchasing and supply management (G1 journals), Operations Management (G2 journals), logistics and transport management (G4 journals) is more evident. G3 journals provide a motley mix of information systems, logistics and supply chain management topics and form a separate (multi-disciplinary group).

As it can be seen in the dendograms, there has been a major change in the role of specific journals. The JSCM for example had a similar role to IJLM in the first ten years, but over the past decade has acquired a different role. Similarly JEIM was similar to SCMIJ in the first decade. As SCMIJ was only introduced in 1995 both
journals acquired a peripheral role in the network. In the second decade *JEIM* has evolved into a more inter-disciplinary journal.

By taking into account other characteristics such as the centrality and betweenness of the journals and by looking at the dendogram between 2001-2010, a conclusion can be reached that the journals that act as gatekeepers between the two major clusters (SCM vs Logistics journals) of the dendogram for 2001-2010 are the *JSCM* and *IJPDLM*.

**Cohesion**
A final analysis has been to identify the cohesion of the network of SCM journals. A way of measuring the cohesion of the whole network is by measuring its density.
The density measure of SNA describes the general level of linkage among actors in a network and is defined as the number of ties in the network divided by the number of pairs of actors (Scott, 2006). As it can be seen in Table VI, the density of the network has increased substantially over the 20 years, illustrating that there has not been a significant change in the structure of the network in terms of its cohesion.

Research findings and discussion

The findings of the SNA analysis generate useful insights about the objectives of this study.

For the selection of a network of journals that represent the intellectual structure of the SCM discipline (Research Objective 1), a large number of journals that increasingly publish articles in the broad field of SCM has been identified. Apart from the seminal disciplines of Logistics, Operations Management and Purchasing, these journals represent a growing interest in SCM phenomena originating in the disciplines of Operational Research, Information Systems, Marketing and General Management. This explosion of interest in supply chain issues provides evidence that the SCM problem domain is being established as an important academic discipline. The selection of the citations from the journals of the selected network also indicated an explosion of interest of the SCM related journal in journals that fall within other disciplines (Research Objective 2).

A discipline's scientific status is enhanced if the knowledge base is widely dispersed and used by other disciplines and researchers (Anderson, 1983). Researchers in the field of SCM draw knowledge on a diverse and very rich body of literature spanning from Operations Management and Logistics to Psychology and Geography. A unique established body of literature regarding supply chain phenomena does not exist and researchers in the field tend to prefer to publish their work in more established general management academic journals. Supply Chain Management related papers are increasingly found in journals such as Harvard Business Review, Strategic Management Journal, and Management Science. These journals in fact are among the most cited journals of the network of journals that have been analysed in this study. Several special issues dedicated to SCM phenomena have been published in these journals with the trend spreading to journals that were traditionally not considered part of the SCM discipline.

For the connections between the selected journals and the identification of the role of the journals in the network, their similarities and the way that their exchange of communication (citations) has changed over time (Research objectives 3 and 4), the SNA analysis revealed the following findings.

Position in the network: Several studies propose that the prominence in a social network is of paramount importance for the diffusion and dissemination of knowledge (Knoke and Song, 2008; Borgatti and Li, 2009). In the analysed network several journals perform this role: The JSCM, SCMIJ, JOM, IJOPM and JEIM have acquired a central role in the network with a focus that transcends the traditional areas of SCM (logistics, procurement, operations). The transformation of the JEIM in particular from a specialised IS logistics journal (Logistics Information Management) to a journal that incorporates a large number of SCM phenomena (Alsudairi and Dwivedi, 2010; Dwivedi and Mustafee, 2010; Schlichter and Kraemmergaard, 2010) has also been
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>0.064</td>
<td>0.068</td>
<td>0.053</td>
<td>0.067</td>
<td>0.069</td>
<td>0.070</td>
<td>0.072</td>
<td>0.066</td>
<td>0.071</td>
<td>0.070</td>
<td>0.066</td>
<td>0.071</td>
<td>0.073</td>
<td>0.077</td>
<td>0.078</td>
<td>0.081</td>
<td>0.083</td>
<td>0.086</td>
<td>0.086</td>
<td>0.085</td>
</tr>
</tbody>
</table>
substantial. These journals can be considered as gatekeepers of knowledge in the scientific community of SCM.

**Clusters in the network:** The findings show that the network of SCM journals has changed considerably over the past 20 years. The 1991-2000 decade was characterised by distinct clusters of journals (see Figures A1, A2, A3, A4, A5 and A6 in Appendix 1) and by a single journal that acted as gatekeeper. The last decade however shows a convergence of communication between the journals and the emergence of larger clusters (that are closer to each other). The distinction between logistics related journals and operations and process management related journals still exists, but there is evidence of convergence. This provides evidence that the network has become more cohesive over the last ten years. Rather than having a few “powerful journals” in the network, the prestige of journals in network is spread across a large number of journals.

The SCM discipline evolved in a way that has been characterised by an increasing need for communication between journals specialising in logistics, transportation, purchasing, operations and process management. Research in Operations Management issues appear to be closer today to SCM as it is evidenced in the analysis. The number of papers that are published in the *JOM* and *IJOPM* with a clear focus on SCM phenomena has increased by 400% over the past 20 years. More and more paper related to SCM are presented in the traditional OM conferences (POMS, EUROMA, INFORMS). The advancements in Information and Communication Technology (ICT) tools over the past decade and the implications of ICT tools on the management of supply chain processes have also

By comparing the SCM discipline to other business disciplines like marketing, Information Systems, or Accounting it can be seen that the SCM discipline is far less concentrated than those disciplines (Baumgartner and Pieters, 2003; Wakefield, 2008; Polites and Watson, 2009). On one hand this may be interpreted as an ever-increasing acceptance of the value of managing inter-organisational systems, which in effect is what SCM stands for. On the other hand though as Pfeffer (1993) postulates, “without a strong network and lack of consensus a discipline’s ability to compete with adjacent disciplines is jeopardized”.

**Conclusion**

In this paper a network of ten academic journals that can be used to represent the academic field of SCM was analysed, with the use of citation data to calculate several SNA metrics (centrality, betweenness, position in the network and network cohesion). The role of each of the journals was identified through the application of SNA in citation data. Based on the findings, several insights have been generated on the way that the SCM has evolved how knowledge and ideas are disseminated in the network.

The evolution of the SCM discipline over the last 20 years represents an interesting case study to analyse how the changes in the marco-economic environment influenced academic research. The way that the field will evolve in the next 20 years with the ever-greater emphasis on inter-disciplinary (and even non-disciplinary) research, represents a great opportunity and challenge for the SCM discipline to acquire a central role in the research in the management of organisational systems. As it is by nature a hybrid field of socio-economic and engineering disciplines, it can provide an ideal
paradigm for greater theoretical and practical advancements for organisations. Published theoretical and applied research in SCM related journals not only will increase the profile of the SCM discipline, but will also create a fascinating forum in which academics can exchange ideas for a variety of pertinent inter-organisational phenomena.

Several implications can be drawn from this study for research in SCM related phenomena.

(1) The exponential growth of interest in SCM phenomena and the growing cohesion of the network of journals is a natural consequence as an academic discipline matures. There needs to be however an increased epistemological and methodological clarity of the problem domain of the SCM discipline.

(2) The distinctive clusters of journals that represent relatively independent approaches to SCM presents an opportunity for the growth of the discipline. At the same time however, without the use of integrated approaches that bridge the conceptually different perspectives (e.g. logistics and operations management), competing paradigms will emerge. The recent stream of research that promotes the sustainability agenda across the supply chain, as well as the strategic notion of value added across the supply chain may provide the integrating theoretical pillars to promote research in SCM.

Limitations and future research

The use of citation analysis for the exploration of the structure of an academic discipline may suffer from several problems, such as the motivation for self-citations as well as citations to particular journals and omission of references. The use of co-citations may be considered also as an ex parte measure of similarity between journals. For the analysis of the intellectual structure of the SCM discipline, its representation by a finite and limited number of journals may carry a certain bias in the understanding of the way that knowledge in an academic discipline evolves.

The main benefit however in using this combinatory bibliometric approach to deconstruct the structure and evolution of the SCM discipline is that its quantitative nature provides an objective perspective and also allows for the identification of specific roles of the selected journals in the way that knowledge is disseminated (Philips and Philips, 1998; Polites and Watson, 2009). This study can be extended and validated with an extensive (qualitative) longitudinal literature review, or a Delphi study.

Further work could use the citation analysis to look at the major academic journals in the general field of management, as well as major practitioner journals, and their relationship with the core journals of SCM. The patterns/importance of the different bodies of literature can be identified through this approach, by measuring the percentages of the citations that refer or come from a journal with a very clear disciplinary orientation. A periodic replication of the study (e.g. every five years) can also be used to reveal any changes in the intellectual structure of the SCM discipline. Future studies can also incorporate newer journals focusing on SCM phenomena.
References


Reed, K.L. (1995), “Citation analysis of faculty publication: beyond Science Citation Index and Social Science Citation Index”, *Bulletin of the Medical Library Association*, Vol. 83 No. 4, pp. 503-8.


**Corresponding author**

Arthur Morgan can be contacted at: Arthur.Morgan@glos.ac.uk