A Review of Research in the *Quality Management Journal:* Influential Resources, Key Themes, and Emerging Trends

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The Quality Management Journal (QMJ) *was established in 1993 to stimulate dialogue between academics studying quality and business leaders actively working to improve it, when the literature on quality management contained primarily empirical studies with a narrow focus and lack of rigor.* QMJ *was conceived to fill this gap, and to serve as a forum for rigorous, original research, while maintaining a strong balance between the development of theory and its application to solving practical problems in a variety of domains. Now that the* QMJ *has been active for nearly two decades, the time is particularly appropriate for a data-driven reflection on what has transpired in the field of quality management through the lens of work published in this journal.*

Using various analytical techniques including a literature review of literature reviews, network analysis, text mining, association analysis, and cluster analysis, this paper identifies: 1) the themes in quality management research explored by the QMJ *since its inception; 2) the most influential resources that researchers have leveraged to draw their conclusions (which includes articles in academic and practitioner journals as well as books); and 3) emerging patterns and trends in the direction of research published in the* QMJ. *Key results are synthesized to make observations about the evolution of quality management research in the* QMJ, *and to identify gaps and emerging trends in the literature to drive future research agendas. Unlike previous published reviews of quality management research, this one is unique in that it focuses on the progress of research captured specifically by the* QMJ.

Key words: citation analysis, data mining, emerging trends, history, literature review, network analysis, research agenda, text mining

INTRODUCTION

The first issue of the *Quality Management Journal (QMJ)* was published in October 1993. The journal was launched with a threefold purpose: to educate executives about the foundations of quality management, to provide researchers with an outlet for their work in quality management, and to provide professionals and managers a venue to keep track of trends in quality management. It was envisioned that *QMJ* would serve as a forum for both researchers and practitioners, and would include both academics and business managers in the review process. However, the founding editor's intention was clear: that *QMJ* would, first and foremost, be a research journal (Golomski 1993). Early supporters agreed that "managerially oriented quality research" was key, and that the *QMJ* would "encourage a more substantive dialogue between academicians and business practitioners" (Benson 1993). The new journal would rectify the imbalance these supporters had noted in the quality management literature, which until that time had been predominantly empirical and heavily weighted toward practice with little emphasis on theory (Flynn, Schroeder, and Sakakibara 1994).

Today, the *QMJ* continues to accept managerially relevant articles from each of the categories in ASQ's quality management body of knowledge (BoK), covering a variety of industries, from manufacturing to

service and education. The average acceptance rate for the journal has consistently hovered between 15 to 20 percent of submissions (Wilson 2009), which is typical for a selective peer-reviewed academic journal in the social sciences (Whitworth and Friedman 2008). After nearly two decades in print, the time is right for solid, research-based reflections on what has transpired in the quality management field that might help propel future research, especially through the lens of the work that has been contributed to the *QMJ*. It is this gap that the present study seeks to partially close.

In its first full 15 years of publication between October 1993 and October 2008, four full-length articles have been published, on average, in each quarterly issue. A total of 261 full-length articles were printed during this time, and contributing authors referenced a total of 6,830 additional references to support their conclusions. A total of 9,433 citation relationships were formed between the articles in *QMJ* and the sources they referenced.

These citation relationships contain a wealth of information about which key articles and concepts have been instrumental in the evolution of research in quality management as presented by the *QMJ*. Using the same mathematical techniques that Google applies to find the top-ranked articles that match one's search criteria, citation relationships made by articles in the *QMJ* can be explored using network analysis to answer questions such as: What resources have been most influential in support of *QMJ* research? What themes or concepts have been highlighted since *QMJ* was first published in 1993? How do these themes or concepts fulfill the gaps in research that were identified when the journal was originally launched?

Although network analysis can be a strong retrospective tool for identifying themes and key resources within the literature, it is less useful for detecting emerging trends. Supplemental approaches such as text mining and classification, which are increasing in popularity for predicting trends (see, c.f., Nature 2011) must be used to tell the rest of the story. Consequently, this study relies on a blend of qualitative and quantitative techniques to synthesize and characterize the landscape of quality management research within the *QMJ* to meet its objectives. These include: 1) a thorough examination of prior reviews of the quality management literature to establish how the field has been conceptualized in the past; 2) analyzing the network of citations made by articles in the *QMJ* to determine the most influential resources and their interrelationships, and to produce a concept map of themes and influential references in *QMJ* research to date; and 3) examining the frequency, patterns, and evolution of words and phrases in article titles to detect emerging trends.

This study makes several important contributions to understanding the quality management literature, and identifying gaps that should be addressed by future articles published in this journal. First, the most popular and most influential resources leveraged by *QMJ* authors are identified. Next, the highest quality *breadth* (hubs) and *depth* (authority) articles are presented. From the relationships between the references, seven *established themes* are identified within *QMJ* research by extracting a concept map using network analysis: international aspects of quality management, service quality, quality culture, impacts of quality management on business results, strategy development, quality tools (such as quality function deployment [QFD]), and validating quality management approaches or techniques. The established theme of strategy development is heavily dependent upon the Malcolm Baldrige National Quality Award (MBNQA) Criteria for Performance Excellence program, hereafter referred to as the Baldrige Criteria.

Using text mining, seven *emerging themes* are also uncovered: international aspects of quality management, relationship of quality management practices to customer satisfaction, teaching and education, improving production quality through leadership and measurement, understanding the linkages between supplier and service quality and voice of the customer, change management and quality culture, and the performance of quality

management practices. Together, the results facilitate a data-driven reflection on the topics studied by *QMJ* researchers, from which gaps are identified and suggestions for future research are offered.

RESEARCH APPROACH

This study combined three research approaches: 1) a network analysis of the connections between citations in the first 15 years of the *QMJ* to uncover influential resources and explore themes; 2) a literature review of previous articles that have aimed to synthesize the state of quality management research (or significant portions of it), many of which were identified via the network analysis, which were used to confirm key themes; and 2) text mining, association analysis, and agglomerative hierarchical clustering to examine emerging trends and patterns in the title and key-word combinations of *QMJ* articles over time. The literature review and network analysis were performed concurrently, with the results from the network analysis informing the selection of key review articles to examine. This section provides additional detail about the two analytical techniques that were applied: citation network analysis and text mining. A more comprehensive examination of the particular data collection and analysis procedures used to support the citation network analysis for this study is provided in Appendix A.

Citation Network Analysis: Centrality and Decomposition Techniques

The practice of examining a network of citations to identify the most prominent research has a long history (Garfield 1964; de Solla Price 1965; Hummon and Doreian 1989). Citation studies can be used to evaluate the impact of an individual, a particular piece of research, or an institution or journal. Networks created from citation data reveal patterns of influence on the development of new concepts and lines of research, the most significant or critical references that form the core of a discipline, and the research themes that define a body of knowledge. (Li-Chun et al. 2006)

For this study, the network of citations formed by the first 15 years of *QMJ* research was explored by: 1) analyzing the *centrality* of articles within the network; and 2) condensing the network into its most critical components to form a concept map, a process called *decomposition*. The most recent three years of *QMJ* research was not analyzed due to the lag effect inherent in network analysis, which tends to favor older and more established resources. Centrality measures suggest which articles or references in a citation network are most important or influential; the structure of the network (also called its topology) can be used to develop concept maps. Additionally, a *k*-core decomposition of the citation network (which extracts only those articles that have been cited by at least *k* other articles *and* are connected to at least one paper that has been cited by another author) was also performed. The decomposition graph was thoroughly inspected and matched to the index of articles to determine which topics were clustered together, to extract key themes from the research. A concept map was constructed from the decomposition and the identified themes.

Centrality Measures

Measures of centrality form the basis for identifying the most influential articles (and other resources) within the citation network. These measures of the relative importance or significance of articles within the network can be computed using several different techniques, each of which applies a unique algorithm for quantifying the importance of an article relative to other articles. Four centrality measures were computed for each resource referenced by *QMJ* researchers: degree centrality, Google PageRank (Brin and Page 1998), and Kleinberg's hub and authority scores (Kleinberg 1999).

Degree centrality is the most simplistic measure of centrality, obtained by counting the number

of incoming citations a reference receives. Even though this is a realistic measure of *popularity,* it is not typically an accurate representation of whether an article is influential (that is, if it is reputable in addition to being popular). It is much more noteworthy to be cited by other important papers that have also received a high number of citations.

Due to this limitation of just reporting the number of incoming citations, alternative algorithms have been developed that take into account the relative importance of the citations a given article receives. The most famous of these is the Google PageRank algorithm, developed by Google founders Sergey Brin and Larry Page. PageRank works by recursively weighting the degree centrality of each node based on the PageRank of the nodes that connect to it. Because each node's PageRank depends on the PageRanks of the other nodes connecting to it, this is a particularly effective measure for assessing the relative importance of a node in the context of all nodes in the network.

Hub and authority scores are simultaneously calculated for each article in the citation network by iteratively adjusting rankings. This is done on the basis that a good authority will be referenced by many hubs, and a good hub will reference many authoritative articles. The idea for this algorithm traces to the early days of the Web, when influential directories like Yahoo (the "hubs") cautiously indexed only the articles they believed were of high quality ("authorities"). Each resource type was influential in a distinctly different way. A high hub score identifies an article that reviews many other authorities in the field. These are often called "review articles" because they synthesize themes in the existing literature and recognize the most significant contributors. A high authority score recognizes articles that are frequently cited, but especially by hubs.

Text Mining, Association Analysis, and Clustering

While network analysis can reveal historical patterns in citation data, the technique is not as capable for detecting emerging trends in the research. To supplement the literature review and network analysis to explore emerging trends, a rudimentary text mining and analysis of *QMJ* titles and key words was performed. Titles and key words were separated into two groups: 1993 to 2008, and 2009 to 2011. There were two reasons for selecting these timeframes. First, the initial 15-year period corresponds to the historical context of the network analysis, and the remaining three years represents a sufficient sample from which emerging trends can be contrasted. Second, the 2009 to 2011 period represents articles that were published after the global economic crisis of October 2008 (Altman 2009), providing a natural demarcation between potentially divergent areas of research interest.

The conceptual process of text mining involves building a collection of unstructured text (called a corpus); preprocessing the data by removing numbers, punctuation, and stopwords (such as "the," "that," "and," "or," and so on); and examining the frequency of words that appear together or in close proximity to one another using correlation profiles (referred to as association analysis). Although sophisticated statistical analysis can be applied to definitively uncover patterns, less formal approaches can be applied to gain a "broad brush" view of similarities and differences. (Feinerer, Hornik, and Meyer 2008) For this analysis, the simple technique of creating wordclouds from term frequency was used to visualize common themes between the two time periods (using *commonality clouds*), as well as contrast differences (through *comparison clouds*).

To identify more subtle patterns within emerging trends, the titles and key words for all *QMJ* articles for calendar years 2009 through 2011 were combined to create a corpus. The data were preprocessed, the least frequent (sparse) terms were removed, and a matrix containing the frequency of occurrence of each of the terms and phrases was rescaled and normalized to ensure comparability. Applying partitioning and agglomerative hierarchical clustering, Euclidean distances between the normalized frequencies were used to distinguish seven trends in the newest *QMJ*

articles. Two of these categories were very similar to one another, and so they were further examined using commonality and comparison clouds. The tm, tau, proxy, and wordcloud packages within the R statistical software package were used to perform the analysis (R Development Core Team 2008).

INFLUENTIAL RESOURCES

To determine which articles and other resources have been most influential in the development of *QMJ* research, the citation network (see Figure 1) was examined mathematically, by using algorithms to rank and sort the articles in terms of breadth, depth, quality, and influence on other articles. Because there is so much information content within the citation network, visual inspection is often not useful, and indeed this is the case for the *QMJ* network. Centrality measures, computed for each article in the network and containing information about an article's significance as compared to other articles in the network, were sorted and ranked to illuminate the most influential resources used by *QMJ* authors.

Most Frequently Cited Articles, Books, and Journals

Degree centrality provides the most straightforward assessment of a resource's influence, that is, how many total citations it has received. The degree centrality for each article in the *QMJ* citation network was computed and the values were compared to one another. The most frequently cited resources are indicated in Table 1, which also displays the number of incoming citations or links (k_{in}) to each article. Next, the number of times each academic journal identified in the sample was referenced was counted. These data are displayed in Table 2.

The top academic journals referenced by *QMJ* are marketing oriented, followed by two management journals that focus on empirical studies and the integration of research results into management practice. The top five is rounded out by

Figure 1 The *Quality Management Journal (QMJ)* citation network.

Technovation, a peer-reviewed publication that covers technological trends and breakthroughs, management of innovation and entrepreneurship, technology transfer, and personal and organizational catalysts for innovation. *QMJ* researchers have mined the marketing literature primarily to understand consumers' perceptions of quality, drivers for satisfaction, and definitions of quality, particularly regarding aspects and dimensions of product quality. Most of the work leveraging *Technovation* as a resource focuses on the innovative development, use, and application of quality tools such as QFD into diverse industries, environments, and cultures. *QMJ* authors have drawn on the management literature primarily for examples of how quality management practices have been implemented in different settings. The Toyota Production System (TPS), for example, has been studied extensively by *QMJ* investigators who have recognized the difficulty organizations have experienced duplicating this socio-technical improvement system. Many seek to bring TPS core concepts of lean and just-in-time production to other domains and industries (for example, Collins and Muthusamy 2007, who explored the applicability of TPS to healthcare).

Sousa and Voss (2002) noted that there are two primary mechanisms through which quality management practice can impact business performance have

Table 1 Top 20 most frequently cited resources in the *QMJ* network.

Rank	k_{in}	Article
1	80	Deming, W. E. 1986. *Out of the crisis.* Cambridge, MA: MIT Center for Advanced Engineering Study.
2	41	Crosby, P. B. 1979. *Quality is free.* New York: McGraw-Hill.
3	37	Juran, J. 1951. *Juran's quality control handbook.* New York: McGraw-Hill.
4	29	Powell, T. C. 1995. Total quality management as competitive advantage: A review and empirical study. *Strategic Management Journal* 16, no. 1:15-37.
5	29	Saraph, J., P. Benson, and R. Schroeder. 1989. An instrument for measuring the critical factors of quality management. *Decision Sciences* 20, no. 4:810-829.
6	29	Nunnally, J. C. 1978. *Psychometric theory.* New York: McGraw-Hill.
7	25	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing* (Spring):12-37.
8	25	Garvin, D. A. 1988. *Managing quality.* New York: Free Press.
9	24	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. A conceptual model of service quality and its implications for future research. *Journal of Marketing* (Fall):41-50.
10	24	Flynn, B. B., R. G. Schroeder, and S. Sakakibara. 1994. A framework for quality management research and an associated measurement instrument. *Journal of Operations Management* 11:39-366.
11	22	Ahire, S. L., D. Y. Golhar, and M. A. Waller. 1996. Development and validation of TQM implementation constructs. *Decision Sciences* 27, no. 1:23-56.
12	22	Feigenbaum, A. V. 1961. *Total quality control: Engineering and management.* New York: McGraw-Hill.
13	22	Senge, P. 1990. *The fifth discipline.* New York: Doubleday.
14	22	Ishikawa, K. 1991. *What is total quality control? The Japanese way.* Upper Saddle River, NJ: Financial Times/Prentice Hall.
15	22	Deming, W. E. 1995. *The new economics for industry, government and education.* MIT Center for Advanced Educational Services.
16	21	Deming, W. E. 1982. *Quality, productivity and competitive position.* Cambridge, MA: MIT Press.
17	20	Juran, J. M. 1989. *Juran on leadership for quality.* New York: Free Press.
18	17	Dean, Jr., J. W., and D. E. Bowen. 1994. Management theory and total quality: Improving research and practice through theory development. *Academy of Management Review* 19, no. 3:392-418.
19	17	Evans, J. R., and W. M. Lindsay. 1989. *The management and control of quality.* St. Paul, MN: West Publishing.
20	16	Flynn, B. B., R. G. Schroeder, and S. Sakakibara. 1995. The impact of quality management practices on performance and competitive advantage. *Decision Sciences* 26, no. 5:659-692.

been systematically evaluated: the manufacturing route, which examines how internal process quality leads to improved performance, and the market route, which explores how to better address customer needs and perceptions of quality. The dominance of marketing, management, and innovation literature in the references of *QMJ* articles suggests that the publication has largely favored the market route to enhanced performance, while further emphasizing strategy to systematically improve quality.

Most Frequently Cited Research Approaches

The full set of results reporting degree centrality rankings was examined to identify which analytical

Table 2 Top 20 most frequently cited academic journals in the *QMJ* network.

Times cited	Journal name
209	Journal of Marketing
170	Journal of Marketing Research
154	Harvard Business Review
136	Technovation
127	Academy of Management Review
109	Quality Management Journal
102	Management Science
91	Journal of Operations Management
65	Academy of Management Journal
58	Journal of Retailing
54	Sloan Management Review
50	Journal of Applied Psychology
50	Strategic Management Journal
49	Administrative Science Quarterly
32	Psychological Bulletin
32	Production and Operations Management
32	Psychological Bulletin
26	Academy of Management Executive
26	International Journal of Quality and Reliability Management
24	Journal of Business Research

techniques and methodologies have been most frequently referenced by *QMJ* authors. Only references with at least 10 incoming citations were considered. As shown in Table 3, the most popular concept that *QMJ* researchers drew from was psychometric theory, which is the study of how to measure psychological constructs such as knowledge, intelligence, personality, educational attainment, and capability. In the *QMJ,* studies that have utilized psychometric theory examine elements of organizational culture, organizational assessment, self-assessment, motivation, perceptions of quality, team dynamics, and leadership.

Table 3 Most frequently cited methodology references in the *QMJ* network.

Times cited	Reference
29	Nunnally, J. C. 1978. *Psychometric theory.* New York: McGraw-Hill.
14	Hair et al. 1995. *Multivariate data analysis.* New York: Macmillan.
11	Cronbach, L. J. 1951. Coefficient alpha. *Psychometrika* 16:297-334.
10	Eisenhardt, K. 1989. Building theories from case study research. *Academy of Management Review* 14, no. 4:532-550.

The internal consistency and reliability of measuring these factors was also a significant focus of *QMJ* researchers, not surprisingly, in particular to validate new survey constructs. For example, Tabladillo and Canfield (1994) developed and validated new management performance measures, and Flynn, Schroeder, and Sakakibara (1995) identified a mechanism to assess the performance of plant operations, and determinants of high and low quality in plant environments. The prevalence of studies that leverage psychometric theory emphasizes the importance of accurately measuring and interpreting hard-to-define factors in quality management, and devising new and rigorous ways to make these measurements.

Multivariate statistical methods have also featured prominently in quality management research. These techniques were applied in empirical studies, most of which aimed to characterize the impact of training, leadership, or attitudes toward and perception of quality to organizational performance and business results. Out of all of the studies that applied multivariate analysis, the techniques of confirmatory factor analysis and principal components analysis (PCA) were overwhelmingly favored, in many cases for data reduction to consolidate survey data into its most significant components of variation (see, for example, Johnson 2004). Other approaches that were used include multiple linear regression, hierarchical clustering, and canonical correlation, although these

Table 4 Top 20 resources in the *QMJ* network Using Google PageRank.

Rank	PR_n	Article
1	20.2	Deming, W. E. 1986. *Out of the crisis.* Cambridge, MA: MIT Center for Advanced Engineering Study.
2	13.7	National Institute of Standards and Technology (NIST). Malcolm Baldrige National Quality Award (MBNQA) Crtieria for Performance Excellence. Gaithersburg, MD.
3	10.8	Deming, W. E. 1982. *Quality, productivity and competitive position.* Cambridge, MA: MIT Press.
4	10.7	Juran, J. 1951. *Juran's quality control handbook.* New York: McGraw-Hill.
5	9.75	Crosby, P. B. 1979. *Quality is free.* New York: McGraw-Hill.
6	7.40	Nunnally, J. C. 1978. *Psychometric theory.* New York: McGraw-Hill.
7	6.85	Finch, B. J. 1999. Internet discussions as a source for consumer product customer involvement and quality information: An exploratory study. *Journal of Operations Management* 17, no. 5:535-556.
8	6.75	Garvin, D. A. 1988. *Managing quality.* New York: Free Press.
9	6.26	Deming, W. E. 1995. *The new economics for industry, government and education.* MIT Center for Advanced Educational Services.
10	5.77	Saraph, J., P. Benson, and R. Schroeder. 1989. An instrument for measuring the critical factors of quality management. *Decision Sciences* 20, no. 4:810-829.
11	5.42	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. A conceptual model of service quality and its implications for future research. *Journal of Marketing* (Fall):41-50.
12	5.38	Juran, J. M. 1989. *Juran on leadership for quality.* New York: Free Press.
13	5.36	Buzzell, R. D., and B. T. Gale. 1987. *The PIMS principles.* New York: Free Press.
14	5.35	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing* (Spring):12-37.
15	5.31	Flynn, B. B., R. G. Schroeder, and S. Sakakibara. 1994. A framework for quality management research and an associated measurement instrument. *Journal of Operations Management* 11:339-366.
16	5.23	Hauser, J. R., and D. Clausing. 1988. The house of quality. *Harvard Business Review* 66, no. 3:63-73.
17	5.19	Senge, P. 1990. *The fifth discipline.* New York: Doubleday.
18	5.16	Groocock, J. M. 1986. *The chain of quality.* New York: Wiley & Sons.
19	5.08	Evans, J. R., and W. M. Lindsay. 1989. *The management and control of quality.* St. Paul, MN: West Publishing.
20	5.04	Montgomery, D. C. 1987. *Introduction to statistical quality control,* second edition. New York: Wiley & Sons.

approaches were used far less frequently than the various techniques of factor analysis.

The case study approach is also popular for research published in the *QMJ,* and several articles use case studies as the basis for developing new theories of quality management, following the guidance of Eisenhardt (1989). Najjar and Bishu (2006), for example, explore differences in service quality across multiple branches of a bank to identify that reliability and responsiveness are two of the most significant aspects of service quality. Other examples, such as Boggs (2004), use the single-case (holistic) design to examine changes in organizational culture.

Most Influential Resources

Degree centrality reveals the most popular resources, but is not a reliable indicator of an

article's true influence because it does not incorporate a measure of the *quality* of the articles providing the incoming citations. For example, if an article is cited by a very important and influential paper, this suggests that the paper is of higher quality than if it was only cited by papers of lesser influence. The relative influence of articles within the citation network was assessed using Google's PageRank algorithm, which identifies the most significant resources based on a combined measure incorporating the frequency and quality of the articles that cite them. Table 4 shows the PageRank results (where individual PageRank scores are labeled PRn).

Google PageRank scores, therefore, indicate which resources have the highest *combination* of quality and popularity, and thus are the most influential within the citation network. As a result, the list of the most influential resources listed in Table 4 contains works by W. Edwards Deming, J. M. Juran, and Phil Crosby, as well as other instantly recognizable works like Garvin's 1988 book entitled *Managing Quality* (which includes his transcendent, product-based, used-based, manufacturing-based, and value-based categorization for defining quality). The Malcolm Baldrige National Quality Program Criteria for Performance Excellence features prominently, as expected. *The Fifth Discipline* (Senge 1990) is also on the list, acknowledging that problem solving using systems thinking—and in particular the notion of individual and collective learning as a means of continuous improvement in organizations—has strongly influenced the development of quality management.

The academic journal articles included in the top-20 list, however, are the ones of greatest interest because they reveal the most significant and foundational concepts underlying contemporary research in quality management. First, understanding the *extent* to which various quality management practices have been applied is of particular importance, because this must be known before causal links can be established between quality management implementation and business results. Saraph, Benson, and Schroeder (1989) provided an instrument to make this determination based on managers' perceptions of quality management implementation at the business unit level, while Flynn, Schroeder, and Sakakibara (1994) focused on how to make this assessment at the plant level. Second, service quality is emphasized in the *QMJ,* grounded in the theory and conceptual model provided by Parasuraman, Zeithaml, and Berry (1988) in the *Journal of Marketing,* and supplemented by the SERVQUAL instrument developed by the same team and presented in the *Journal of Retailing* (Parasuraman, Zeithaml, and Berry 1988). Third, the relationship between implementing quality management practices and enhancing competitive advantage is highlighted by the inclusion of Buzzell and Gale's (1987) book on the linkages between strategy and performance, derived from studies of the Profit Impact of Market Strategies (PIMS) database. This repository of information (now accessible from http://pimsonline.com) is still being used for research. However, in examining the challenges associated with using PIMS to draw causal links, Mosqueda Almanza and Tomas (2011) point out that there remain two significant frontiers of exploration: understanding how strategy and performance are mediated by: 1) changes in product quality and perceptions of product quality over time, and 2) changes in the evolution of the market within which a business is embedded.

Finally, the inclusion of Finch's (1999) article on mining the Internet as a potential means of obtaining information and feedback from customers is curious. Finch (2000), which extends the 1999 article, provides a case study based on tracking the mentions made to a tool manufacturer on Internet-based Usenet newsgroups. Although the articles receive few citations, and they reference a rather antiquated approach to mining data from the Internet, the fact that this article received a high PageRank indicates that using information on the Internet to identify customer and consumer perceptions of quality is starting to influence the quality management literature in some way, and this connection should be further explored.

Table 5 Top 20 hubs in the *QMJ*.

Rank	HU_n	Article
1	100	Ford, M. W., and J. R. Evans. 2000. Conceptual foundations of strategic planning in the Malcolm Baldrige Criteria for Performance Excellence. *Quality Management Journal* 7, no. 1:8-26.
2	63.1	Issac, G., C. Rajendran, and R. N. Anantharaman. 2004. A holistic framework for TQM in the software industry: A confirmatory factor analysis approach. *Quality Management Journal* 11, no. 3:35-60.
3	58.5	Jabnoun, N., A. Khalifah, and A. Yusuf. 2003. Environmental uncertainty, strategic orientation, and quality management: A contingency model. *Quality Management Journal* 10, no. 4:17-31.
4	54.6	Issac, G., C. Rajendran, and R. N. Anantharaman. 2004. Significance of quality certification: The case of the software industry in India. *Quality Management Journal* 11, no. 1:3-32.
5	50.5	Grandzol, J. R., and M. Gershon. 1997. Which TQM practices really matter: An empirical investigation. *Quality Management Journal* 4, no. 4:43-59.
6	48.3	Balbastre Benavent, F. 2006. TQM application through self-assessment and learning: Some experiences from two EQA applicants. *Quality Management Journal* 13, no. 1:7-25.
7	48.2	Kujala, J., and P. Lillrank. 2004. Total quality management as a cultural phenomenon. *Quality Management Journal* 11, no. 4:43-55.
8	46.5	Ryan, C., R. H. Deane, and N. P. Ellington. 2001. Quality management training in small to midsized manufacturing firms. *Quality Management Journal* 8, no. 2:44-52.
9	46.2	Sun, H. 2001. Comparing quality management practices in the manufacturing and service industries: Learning opportunities. *Quality Management Journal* 8, no. 2:53-71.
10	43.8	Handfield, R., S. Ghosh, and S. Fawcett. 1998. Quality-driven change and its effects on financial performance. *Quality Management Journal* 5, no. 3:13-30.
11	41.7	Jain, B., and F. Tabak. 2002. Organizational quality management in emerging economies. *Quality Management Journal* 9, no. 2:10-24.
12	40.5	Cameron, K., and W. Sine. 1999. A framework for organizational quality culture. *Quality Management Journal* 6, no. 4:7-25.
13	40.4	Prajogo, D. I., and A. Brown. 2004. The relationship between TQM practices and quality performance and the role of formal TQM programs: An Australian empirical study. *Quality Management Journal* 11, no. 4:31-42.
14	37.6	Martinez-Lorente, A. R., A. Gallego-Rodriguez, and B. G. Dale. 1998. Total quality management and company characteristics: An examination. *Quality Management Journal* 5, no. 4:59-71.
15	37.3	Witcher, B. 1995. The changing scale of total quality management. *Quality Management Journal* 2, no. 4:9-29.
16	36.8	Pinar, M., and C. Ozgur. 2007. The long-term impact of ISO 9000 certification on business performance: A longitudinal study using Turkish stock market returns. *Quality Management Journal* 14, no. 4:21-40.
17	35.8	Schniederjans, M. J., M. M. Parast, M. Nabavi, S. S. Rao, and T. S. Raghu-Nathan. 2006. Comparative analysis of Malcolm Baldrige National Quality Award Criteria: An empirical study of India, Mexico, and the United States. *Quality Management Journal* 13, no. 4:7-21.
18	35.7	Masters, B., and G. V. Frazier. 2007. Project quality activities and goal setting in project performance assessment. *Quality Management Journal* 14, no. 3:25-35.
19	35.4	Huff, L., C. Fornell, and E. Anderson. 1996. Quality and productivity: contradictory and complementary. *Quality Management Journal* 4, no. 1:22-39.
20	34.0	Barringer, B., S. T. Foster Jr., and G. Macy. 1999. The role of quality in determining export success. *Quality Management Journal* 6, no. 4:55-70.

Table 6 Top 20 authorities in the *QMJ* network.

Rank	AU_n	Article
1	100	Deming, W. E. 1986. *Out of the crisis*. Cambridge, MA: MIT Center for Advanced Engineering Study.
2	56.4	Crosby, P. B. 1979. *Quality is free*. New York: McGraw-Hill.
3	52.2	Powell, T. C. 1995. Total quality management as competitive advantage: A review and empirical study. *Strategic Management Journal* 16, no. 1:15-37.
4	49.7	Saraph, J., P. Benson, and R. Schroeder. 1989. An instrument for measuring the critical factors of quality management. *Decision Sciences* 20, no. 4:810-829.
5	38.1	Flynn, B. B., R. G. Schroeder, and S. Sakakibara. 1994. A framework for quality management research and an associated measurement instrument. *Journal of Operations Management* 11:339-366.
6	37.7	Ahire, S. L., D. Y. Golhar, and M. A. Waller. 1996. Development and validation of TQM implementation constructs. *Decision Sciences* 27, no. 1: 23-56.
7	33.2	Nunnally, J. C. 1978. *Psychometric theory*. New York: McGraw-Hill.
8	32.2	Juran, J. 1951. *Juran's quality control handbook*. New York: McGraw-Hill.
9	31.5	Dean, Jr., J. W., and D. E. Bowen. 1994. Management theory and total quality: Improving research and practice through theory development. *Academy of Management Review* 19, no. 3:392-418.
10	31.4	Feigenbaum, A. V. 1961. *Total quality control: Engineering and management*. New York: McGraw-Hill.
11	28.8	Ishikawa, K. 1991. *What is total quality control? The Japanese way*. Upper Saddle River, NJ: Financial Times/Prentice Hall.
12	28.2	Juran, J. M. 1989. *Juran on leadership for quality*. New York: Free Press.
13	28.0	Garvin, D. A. 1988. *Managing quality*. New York: Free Press.
14	27.5	Hendricks, K., and V. Singhal. 1997. Does implementing an effective TQM program actually improve operating performance? Empirical evidence from firms that have won quality awards. *Management Science* 43, no. 9:1258-1274.
15	26.9	Black, S. A., and L. J. Porter. 1995. Identification of the critical factors of TQM. *Decision Sciences* 27, no. 1:1-21.
16	26.4	Flynn, B. B., R. G. Schroeder, and S. Sakakibara. 1995. The impact of quality management practices on performance and competitive advantage. *Decision Sciences* 26, no. 5:659-692.
17	22.6	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. A conceptual model of service quality and its implications for future research. *Journal of Marketing* (Fall):41-50.
18	22.1	Parasuraman, A., V. A. Zeithaml, and L. L. Berry. 1988. SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing* (Spring):12-37.
19	21.9	Samson, D., and M. Terziovski. 1999. The relationship between total quality management practices and operational performance. *Journal of Operations Management* 17:393-409.
20	21.9	Phillips, L. W., D. R. Chang, and R. D. Buzzell. 1983. Product quality, cost position, and business performance: A test of some key hypotheses. *Journal of Marketing* (Spring):26-43.

Hubs and Authorities

While degree centrality and PageRank suggest which resources are the most popular and the most influential, respectively, Kleinberg's hub and authority scores highlight the articles that are the most comprehensive. Hubs and authorities are identified, mathematically, by their mutual relationships to one another: a good hub points to many authoritative resources (or authorities), and a good authority is cited by several good hubs. A high hub score reveals an article that demonstrates *breadth* and high

quality, whereas a high authority score emphasizes an article's combined *depth* and high quality. Table 5 shows the most highly ranked hubs in the *QMJ* citation network, and Table 6 lists the authorities.

The hub scores, as expected, revealed which articles *within the QMJ* present the broadest and most influential reviews of key topics. The top hub score is associated with a paper by Ford and Evans (2000) which explains how the dimensions of the Baldrige Criteria align with the theoretical basis for strategic planning from the management literature. Managers who seek to apply the Baldrige Criteria in their organizations would be well served by reading this article to understand the theoretical relationships between how elements of the criteria are applied in practice. Two of the top five hubs explore quality management as applied to the software industry, suggesting the increased interest of the community since 2004 (when the article was originally published) in bringing the insights from quality management research into this new domain. Ranked third among hubs, Jabnoun, Khalifah, and Yusuf (2003) proposes a *contingency model* for understanding how an organization's strategic stance (passive or "defender," balanced or "analyzer," and aggressive or "prospector") relates to the uncertainty of its market environment and its choice of quality management approaches. Although proposed as a general model, its prominence as a top-ranked hub suggests that it deserves further exploration as the basis for more targeted, empirical studies.

The authority score can be used to extract the most influential *in-depth* resources from the citation network, and for this reason it is recommended as a preferred measure of prominence within the network over Google PageRank. As expected, several of the "quality gurus," including Deming, Juran, and Crosby, are ranked highly because their work is broad, philosophical, comprehensive, or weaves together multiple themes. Deming's *Out of the Crisis* (1986) consistently appeared as the single most influential resource in the development of quality management understanding using various centrality measures, earning it the honor of being the single most influential resource for *QMJ* researchers. Not surprisingly, Feigenbaum's *Total Quality Control,* Juran's *Quality Handbook,* and Crosby's *Quality is Free* also featured prominently as top-ranked resources. Even in the most recent research, the influence of the field's original thinkers is still pronounced, and their tenets are not often questioned. With the extensive expansion of quality management practice from its origins in manufacturing into service, healthcare, high-tech, and other industries over the past two decades, coupled with the broad social and political changes that have been brought on by globalization and internetworked lives, the social context of quality management has evolved substantially. As a result, more critical examinations of the validity of the gurus' claims and theoretical perspectives in the modern social and economic context may be warranted.

KEY THEMES

To identify key themes in the research through the lens of work in the *QMJ,* a three-part process was applied. First, top-ranked articles in terms of PageRank, hub score, or authority score were examined to determine which papers contained extensive reviews of the quality management literature, or which were expressly written to provide a historical evaluation, identify gaps, and/or propose research agendas for moving forward. This resulted in four results; one was excluded because it did not provide recommendations for future research. Next, the full list of 7,090 references used by *QMJ* authors between 1993 and 2008 was searched for the key words "literature," "review," and "agenda." This yielded an additional three results. After searching *QMJ* articles in ASQ's Quality Information Center (QIC) since 2008, two additional articles were found, and Google Scholar was used to find four additional review articles that have not yet been leveraged to support research in *QMJ*. One article was excluded (Lofgren and Witell 2008) due to its focus on a very narrow aspect of quality

Table 7 Reviews of the quality management literature since launch of *QMJ*.

Author(s)	Topic(s)	Identified Using:
Flynn, Schroeder, and Sakakibara (1994)	Quality management	QMJ Authorities
Ahire, Landeros, and Golhar (1995)	Quality management	QMJ Network
Samson and Terziovski (1999)	Quality management, performance	QMJ Authorities
Parasuraman and Zinkhan (2002)	Service quality, collaborative supply chain management	QMJ Network
Sousa and Voss (2002)	Quality management	QMJ Network
Seth, Deshmukh, and Vrat (2004)	Service quality	Google Scholar
Brady and Allen (2006)	Six Sigma	Google Scholar
Chong et al. (2010)	Quality management, knowledge management, collaborative supply chain management	Google Scholar
Luzon and Pasola (2011)	Quality management, innovation	Google Scholar
Tari (2011)	Quality management, social responsibility	Google Scholar
Zhang, Hill, and Gilbreath (2011)	Six Sigma	ASQ QIC

management—"Kano's Theory of Attractive Quality." Consequently, a total of 11 reviews of the research were examined. These results were evaluated in the context of the *k*-core decomposition of the *QMJ* citation network to determine strengths of *QMJ* research over the past two decades and opportunities for future exploration.

Reviews of Research in Quality Management Since 1993

Thirteen review articles, published between 1993 and 2011, were identified and examined to understand the various perspectives that have been taken in the framing of current and future research in quality management over this time period. They are summarized in Table 7, and organized by year published. Note that the citation network analysis is most effective in identifying review articles that have been recognized and widely cited over time, but it is not as useful in detecting more recent influential reviews. Despite the utility of relatively new algorithmic approaches for identifying critical resources and key themes, there is no substitute for qualitative judgment to assess the relative merit of publications in the advancement of a field of research (Maslov and Redner 2009).

Several studies have attempted to use their literature reviews to identify key dimensions of quality management practice. Flynn, Schroeder, and Sakakibara (1994) proposed seven aspects to serve as the basis for their assessment instrument, focused on evaluating quality performance at the plant level: top management support and leadership, quality information (that is, feedback and process control in production), process management, product design, workforce management, supplier involvement, and customer involvement. They acknowledge that these categories are similar to the Baldrige Criteria, but do not offer an explanation why certain sections (for example, business results) are not included. Aside from encouraging researchers to continue exploring the validity and reliability of their proposed assessment tool, there were very few opportunities presented for future research. Although these authors identified that an instrument to measure quality performance from the perspective of customers would be useful, as well as one to assess the value of various quality management practices from the perspectives of different stakeholder

groups within the organization, this author did not uncover evidence that such efforts have since been undertaken. The main contribution of Flynn, Schroeder, and Sakakibara (1994) was to provide a valid and reliable assessment tool for evaluating quality performance at the plant level along the seven dimensions that were identified. Practitioners can apply this, or if the desired level of analysis is the business unit, the assessment constructs proposed by Saraph et al. (1989) as an alternative.

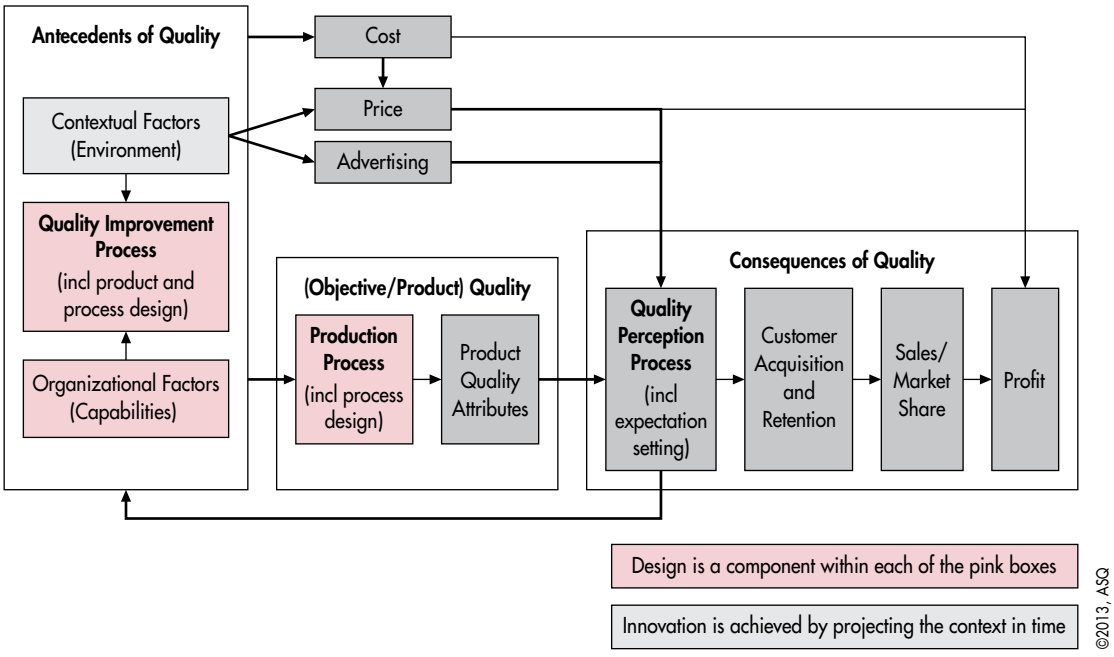
Ahire et al. (1995) asserted that as of the mid-1990s, there was no "sound theoretical framework classifying past efforts and guiding future research." Using the Baldrige Criteria as a classification framework, rather than extracting a new framework as a consequence of their analysis, they conclude that the prior research had been heavily weighted toward concept development with little attention paid to hypothesis generation and theory development. This is consistent with the observations of the original editors who launched *QMJ,* as well as the early contributions of the quality gurus, which continue to be referenced heavily despite their anecdotal and situational nature of many of their conclusions.

The most significant contribution from Ahire et al. (1995) was a list of potential research topics for each of the categories in the Baldrige Criteria. Measuring the level of top management commitment and determining the relative importance of leadership behaviors in quality-driven organizations, across firms and across industries, was noted as an important area of leadership to investigate. Regarding information and analysis, their recommendations focused on developing a more structured and systematic approach to selecting processes to benchmark and determining benchmarking strategies. With respect to strategic quality planning, they emphasized that decision support systems could be better leveraged to formulate quality strategies. Furthermore, differences between firms and across industries as quality strategies are developed and deployed should be better understood. In the area of human resource management, researchers were encouraged to explore contingency models to determine how contextual factors like an organization's size, environment, and technology might impact the deployment of quality management practices. Process quality was also discussed, in particular the need for an integrated understanding of quality assurance and pre-production elements of designing quality into processes and products. In the area of business results, the authors identified a need to further explore customer-supplier linkages, especially in the realm of new product development, and to gain a better understanding of the time lag between implementing quality strategies and realizing results. Regarding customer focus, the need to identify how different internal and external factors and constituents come together to assess customer needs (and deliver based on those needs) was highlighted.

Several of these thematic issues, as well as the exploration of the time lag issue as it relates to systematic changes in product quality, were addressed by Mitra (2003). By systematically analyzing more than 300 journal articles about quality and quality improvement, primarily from the marketing perspective, he noted many different perspectives on the definitions of quality and aimed to synthesize them all into a dynamic framework. He found that there were five stages of the dynamic process of achieving and improving quality:

- **Organizational antecedents**—creating an organization whose capabilities can support achieving world-class quality in products and services
- **Operational antecedents**—designing quality into products, managing processes to achieve quality
- **Production quality**—meeting specifications for features, reliability, and performance; adequately addressing aesthetics and customer taste preferences to create demand
- **Customer consequences of quality**—whether and how customers perceive quality, and how this impacts retention

Figure 2 A dynamic framework for understanding relationships between dimensions of quality (adapted from Mitra 2003).



- **Market consequences of quality**—in terms of market share, as well as the impact of quality and quality improvement on its contribution to profitability and global competitiveness

Using the framework he developed (see Figure 2), he explored the relationship between customer perceptions of quality and the time lag in different market segments, adjusted based on a firm's reputation for quality. By determining when quality increases or decreases occurred, and when they were recognized by consumers and finally impacted business results, he found that across many different product categories, it can take up to six years for changes in product quality to impact business results. An expanded version of the study was presented by Mitra and Golder (2006).

Samson and Terziovski (1999) explored the relationship between aspects of TQM implementation and operational performance using information from more than 1,200 manufacturing companies in Australia and New Zealand. Their results supported the conclusions of Ahire et al. (1995) that product quality was very closely tied to the implementation of quality practices in human resource management, and contend that the performance of the organization depends greatly on such "soft" factors. They discussed the time lag between implementing an improvement, and being able to detect the results from that improvement, as a key limitation. They recommended that longitudinal studies could potentially close that gap.

Sousa and Voss (2002), following an approach used by earlier researchers such as Flynn, Schroeder, and Sakakibara (1994), used their analysis to classify the literature into five research streams: the definition of quality management, the definition of product quality, the impact of quality management on performance (at the firm level), quality management in the context of management theory, and the implementation of quality management practices. A comparison of some of the frameworks used is shown in Table 8. They noted that there had been no convergence in the definition of product quality at that time, a challenge that Mitra (2003) partially satisfied. Most significantly, they suggested that increased effort should be applied to exploring the expansion of the quality

Table 8 Comparison of frameworks for conceptualizing quality management.

Description	ASQ CMQ/OE BoK	Baldrige Criteria	Flynn et al. (1994)	Sousa and Voss (2002)
Leadership for Quality	X	X	X	
Strategic Planning for Quality	X	X		
Customer and Market Focus	X	X	X	
Information and Analysis		X	X	
Workforce Focus/Training and Development	X	X	X	
Process Management		X	X	X
Business and Quality Results		X		X
Tools for Quality Improvement	X			
General Philosophies and Theories				X
Definitions of Quality				X
Supplier Involvement			X	
Product Design			X	X

award assessment frameworks (for example, into social responsibility, although this domain was not specifically mentioned) and the introduction of new techniques such as Sitkin, Sutcliffe, and Schroeder's (1994) total quality learning (TQL).

Parasuraman and Zinkhan's (2002) article is unique in the collection of reviews that were explored. As editors of the *Journal of the Academy of Marketing Science,* they prepared a special edition to explore the relationship between rapid advances in technology (specifically, as a result of the Internet) and consumer perceptions. Several of the articles in this edition are of practical relevance to researchers in quality management, including one by Zeithaml et al. (2002) on the topic of conceptual models for linking service quality to customer satisfaction in the online environment. Seth et al. (2004) also emphasize the importance of understanding the impact of technology on quality in the service setting, and present 19 different conceptual models for service quality that could be leveraged to explore, in more detail, the relationships between supplier quality, service quality, and dimensions of customer satisfaction.

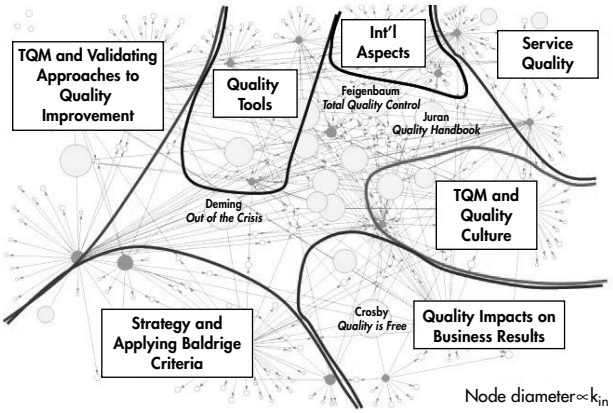
Chong et al. (2010) also conducted an extensive review of the literature, finding that many researchers had responded to the theme of how advances in technology were impacting the implementation and success of quality management practices. They examined the emerging trend of collaborative supply chain management, and drew the conclusion that not only was effective knowledge management an important antecedent for making this process successful, but that it could provide a fertile ground for promoting innovation. As a result, they encouraged continued theory development and empirical research linking specific TQM practices, knowledge management, and innovation.

There have been two recent reviews of Six Sigma research in the context of quality management practice. Brady and Allen (2006) examined 201 articles published between 1990 and 2003. They found that Six Sigma was strong as a basis for cultivating and maintaining management support, and for promoting data-driven problem solving in organizations, especially among staff with limited background in this area. They suggested that developing better contingency models for "clarifying

which techniques are most applicable in which situations" was essential. Zhang et al. (2011) provided an expanded review of the Six Sigma literature for *QMJ,* considering 507 peer-reviewed journal articles, the majority of which were from practitioner journals. They advocated a greater focus on Six Sigma from the perspectives of organizational science (including learning theory) and leadership development. Most significantly, they noted that Six Sigma provides a valuable context for exploring innovation, and argued that using Six Sigma can promote high organizational ambidexterity. Luzon and Pasola (2011) reached a similar conclusion in their exploration of organizational ambidexterity (the ability to continually improve existing processes while simultaneously adapting to and anticipating future change) and its relationship to TQM practices. Making an interesting connection, they also supported the notion introduced by Samson and Terziovski (1999) that soft factors are far more critical for successfully achieving organizational ambidexterity, a linkage that could be very powerfully explored from within the context of quality management theory and practice.

Finally, a review of the literature linking quality management and social responsibility was published in the *Journal of Business Ethics* by Tari (2011), calling for a new research front in this area. He notes that the foundations for corporate social responsibility (CSR) are deeply embedded in the Baldrige Criteria, indicating that social responsibility could be operationalized more easily into organizations whose management models use the criteria. However, the only resource cited by this review from the *QMJ* was Ascigil (2010), who explored the integration of social responsibility into management practices in two firms in Turkey, finding that it is possible to "adopt" CSR and derive value from its marketing aspects while ignoring the necessary transformation of management practice. Much more work is needed to determine how specific practices for corporate social responsibility can be embedded into quality management (what to do), and what considerations will yield practical and tangible benefits.

Figure 3 Conceptual themes in the three-core decomposition of the *QMJ* network.



Analytical Identification of Key Themes

This historical examination of themes was supported by a mathematical extraction of dominant themes, by creating a concept map using the technique of *k*-core decomposition applied to the *QMJ* citation network. A value of 3 was chosen for *k,* meaning that only resources cited by at least three other papers and connected to the main body of articles cited were included. The decomposition graph is shown in Figure 3. The first pattern that is evident is the tight cluster in the middle, anchored by many of the authorities in the network, including Deming's *Out of the Crisis,* Feigenbaum's *Total Quality Control,* and Juran's *Quality Handbook.* It is not surprising that the contributions of the quality gurus feature so prominently in the condensed network of the concept map, nor that they appear to uniformly influence each of the themes, since each of their contributions is fundamental, broad, and comprehensive. Crosby's *Quality is Free* is not in the central core, suggesting that his philosophy of zero defects has not been as central to the development of research in the *QMJ*.

Dominant conceptual themes were determined by thoroughly inspecting the content of the articles that appeared, as nodes in the network, in each section of the concept map. As expected, articles and resources with interrelated topics tended to be clustered together. Seven established themes within the *QMJ* were identified: 1) international aspects of quality management; 2) service quality; 3) TQM and quality culture; 4) the impacts of quality management practice on business results; 5) strategy development and applying the Baldrige Criteria; 6) TQM and validating the effectiveness of different approaches to quality management; and 7) the application of quality tools (such as QFD) in different environments and industries. Although many quality philosophies and award programs could have been used as the basis for exploring successful strategy development, Baldrige was overwhelmingly favored by *QMJ* authors for this purpose. Crosby's *Quality is Free* is clustered with the section on business results, suggesting that his philosophy has been most frequently connected to studies that link production quality and business performance.

Three of these seven established themes (quality tools, strategy development, and business results) are also components of the Baldrige Criteria and the ASQ CMQ/OE Body of Knowledge categories, as outlined in Table 8. However, there are several categories within these two frameworks that were not broadly addressed by *QMJ* researchers by the end of 2008, including leadership, customer and market focus, information and analysis, process management, definitions of quality, and the combined impact of a human resource focus plus training and development. It is important to note that although these elements are not distinctly observable as themes in the research of the *QMJ* according to this analysis, key words related to these categories do appear frequently in the citation network, suggesting that *QMJ* researchers have addressed these issues from within the context of the seven established themes. Analysis of themes also shows that researchers have been actively attempting to validate various approaches to quality management practice, especially those derived from TQM. As a result, *QMJ* researchers have followed the advice of Flynn, Schroeder, and Sakakibara (1994) and Ahire et al. (1995) and extended the quality management literature as recommended, testing hypotheses and assessing quality management practices in an attempt to resolve both what to do and how to do it (Sousa and Voss 2002).

The remaining three established themes uncovered within the concept map are new. These unique themes that have been embraced by the *QMJ* are international aspects of quality management practice, service quality, and quality culture. The prominence of these categories in the citation network analysis indicates that they may be critical themes in the body of contemporary research in quality management. The placement and proximity of the categories indicates which topics are more related to one another, and which topics are dissimilar. Because these three unique themes all appear on the right side of Figure 2, papers in these areas do not draw as much from the literature clustered on the left side, namely strategy development and validation of quality management practices in different settings. As a result, there appear to be opportunities to tie the international situation of quality management practices and service quality considerations more strongly to strategy development, or to insights that could be gleaned from resources like the Baldrige Criteria.

There are other interesting conclusions that can be drawn from the concept map. For example, the resources focusing on quality culture are flanked by the ones that address service quality and business results. This emphasizes that elements of quality culture, or perhaps even aspects of TQM, may be instrumental as mediator variables to explain how or why certain business results can be achieved in service settings. Similarly, the placement of the business results category in between strategy development and quality culture emphasizes that both aspects have been demonstrated to be critical in the achievement (or failure to achieve) desired business outcomes.

EMERGING TRENDS

Despite revealing three unique foci in the history of *QMJ* research (international aspects of quality management practice, service quality, and quality culture), it is not possible to project future research fronts without an idea of which topics are emerging as significant. To help diagnose this aspect of *QMJ* research, analytical techniques from text mining were used to compare and contrast the titles and key words of articles over the period of the citation network analysis (1993 to 2008) and beyond (2009 to 2011). This demarcation aligns with the global economic collapse of late 2008, making the results from this analysis sensitive to changes in the external environment that might influence the selection and development of new research.

The analysis was completed in three stages: first, word clouds were constructed to illuminate the similarities and differences between articles in the two periods. Next, the most frequent terms in each group were extracted. Association analysis was used to determine the correlations between the frequency of concurrent occurrence of two terms or phrases for the most recent *QMJ* articles. Finally, agglomerative hierarchical clustering was used to reveal the key themes and categories in recent *QMJ* research, providing a basis for comparison with the key themes map generated by analyzing the citation network for the first 15 years of the journal.

Similarities between the two time periods were captured in a commonality cloud, shown in Figure 4, and differences were highlighted using a comparison cloud, displayed in Figure 5. As expected, *QMJ* researchers focus on quality and

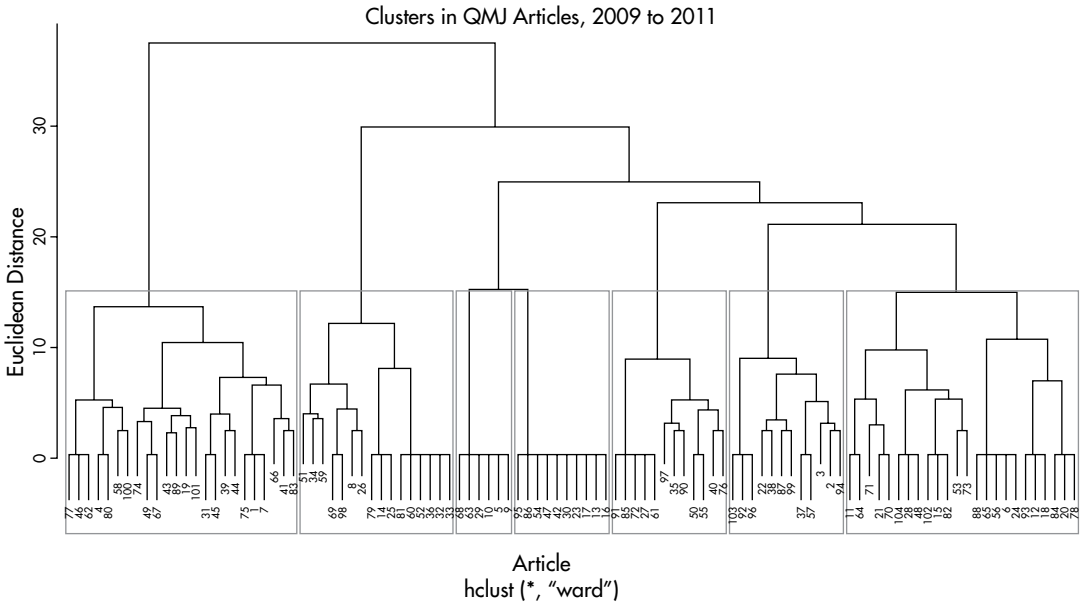
Figure 4 Commonality cloud highlighting the overall themes in *QMJ* title and key words.

Figure 5 Comparison cloud illuminating the differences between titles and key words in its first 15 years versus the most recent three years.

Table 9 Association analysis (correlations) for co-occurrence of terms in 2009-2011 *QMJ* titles and keywords.

analysis 1	factor 0.4	cause 0.34	effect 0.34	examiner 0.28	managing 0.28	regression 0.28	process 0.24	
customer 1	requirements 0.52	expectation 0.39	focus 0.39	customer satisfaction 0.37	service quality 0.35	market 0.33	supplier 0.33	
supplier quality 0.33	attributes 0.27	relationships 0.27	retention 0.27	understanding 0.27	voc 0.27	voice 0.27		
customer satisfaction 1	customer 0.37	services 0.33	voc 0.33	voice 0.33	requirements 0.31	service quality 0.3		
international 1	tqm 0.49	globalization 0.29	china 0.24	educational 0.24	effective 0.24	european 0.24	gepm 0.24	
global 0.24	india 0.24	measurements 0.24	mexico 0.24	self-assessment 0.24	students 0.24	united 0.24		
industry 1	software 0.55	financial 0.49	maturity 0.42	capability 0.37	cmm 0.34	healthcare 0.34	software quality assurance 0.34	sqa 0.34
lean 1	integrated 0.7	jit 0.7	literacy 0.7	maintenance 0.7	productive 0.7	time 0.7	total 0.7	
tpm 0.7	innovation 0.49	presentation 0.49	qms 0.49	selection 0.49	techniques 0.49	manufacturing 0.39	program 0.39	
training 0.39	financial 0.34	improving 0.34	project 0.34	higher education 0.3	research 0.3	system 0.27	management 0.25	
six sigma 0.21								
management 1	project 0.36	styles 0.36	program 0.31	example 0.25	lean 0.25	managing 0.25	supply chain 0.25	
understanding 0.25	perspective 0.24	planning 0.24	success 0.24					
performance 1	appraisals 0.36	organizations 0.29	results 0.27	firms 0.25	indicators 0.25	kpis 0.25	maturity 0.25	objectives 0.25
process 1	cpk 0.37	index 0.37	capability 0.28	effect 0.28	failure 0.28	program 0.28		
servicequality 1	service 0.54	financial 0.36	measuring 0.36	perspective 0.36	retention 0.36	voc 0.36	voice 0.36	
customer 0.35	information 0.31	customer satisfaction 0.3						
six sigma 1	applying 0.45	return 0.45	roi 0.45	investment 0.36	results 0.36			
tqm 1	international 0.49	organizational 0.33	globalization 0.31	effectiveness 0.25	experiences 0.25	iso 0.25	qms 0.25	
understanding 0.25	awards 0.24	commitment 0.24	focus 0.24					
education 1	educational 0.62	engineering 0.62	students 0.62	training 0.5				
higher education 1	educational 0.62	measuring 0.62	students 0.62	american 0.44	belt 0.44	benchmarking 0.44	black 0.44	
certified 0.44	computer 0.44	computers 0.44	cssbb 0.44					

Figure 6 Agglomerative hierarchical clustering of titles and key words, 2009 to 2011, into seven emerging themes. (More information about the content of the clusters is available at http://nicoleradziwill.com/qmj).



management, with a strong emphasis on using the constructs from quality award programs such as the MBNQA. TQM also figures prominently, emphasizing its applicability as an organizing framework from which much research has grown. Culture, customers, and customer satisfaction have remained strong topics, as well as understanding how quality management practices can be successfully implemented across industries.

The comparison cloud shows how the research focus has changed within the *QMJ* since the end of 2008. In addition to showing which topics have surged to the forefront, the key words in the 1993 to 2008 portion of the cloud indicate which areas used to be dominant, but are no longer emphasized as strongly. Several trends can be noted. First, emphasis on quality improvement and continuous improvement is waning due to a renewed focus on enhanced performance and business results. Not surprisingly, this reflects the current economic reality, where even improvement efforts must be firmly grounded in the tangible value they must deliver. Certification is noted in the comparison cloud, suggesting that the value of certification and its relationship to achieving business results is of interest. The concept of key performance indicators (KPIs) also appears in the comparison cloud, indicating a renewal of interest in that topic. Customer focus, customer satisfaction, service quality, and excellence are also becoming more prominent, as well as a focus on the domain of service quality. International aspects of quality management practice, although present as a key theme in the first 15 years of *QMJ* research, have become even more prominent over the past few years as economic changes impact the structure of markets and supply chains.

Association analysis presents the correlation between two terms appearing in close proximity to one another. Selected results from the association analysis are presented in Table 9. These results show, for example, China, India, and Mexico are the countries most frequently studied in analysis of international quality management practices; that there is a strong tie between the concepts of customer satisfaction and supplier quality; that the two predominant emerging industries where quality management is being applied in greater frequency are healthcare and software; that service quality

is strongly tied to the notion of customer satisfaction and retention; and that performance is often explored in the context of business results and the maturity of an organization. The correlations from association analysis were used to interpret the clustering results, which are now described.

Agglomerative hierarchical clustering was applied to the collection of recent titles and key words to further illuminate the contrasts seen in the comparison cloud. First, a partitioning scheme was applied to identify the optimal number of seven clusters for this group, after which additional clusters do not significantly reduce the sum of squares of residuals between an item in the group and its cluster center. Euclidean distances were computed between the scaled frequency of terms, and Ward's method (Murtagh and Legendre 2011) was applied to segment the documents based on their dissimilarity to one another. The clustering results are shown in Figure 6.

The clustering results must be further processed to infer meaning from the derived clusters. To do this, word clouds for each of the seven clusters were produced to characterize dominant themes, and a comparison cloud was generated to determine the key words that distinguished between two very similar clusters (Radziwill 2012). Patterns in the proximity and frequency of key words were used to describe the themes, some of which were previously observed in *QMJ* research, and examined in the context of the correlations from the association analysis to confirm results. The following entries that have not been previously observed as themes are the *emerging themes,* and are indicated in italics:

- International aspects of quality management
- Relationship of quality management practices to customer satisfaction
- Change management and quality culture
- The performance of quality management practices in different contexts
- *Teaching and learning in quality management, and quality management practice in education*
- *Improving production quality through leadership and measurement of perceived quality along multiple dimensions*
- *Understanding the linkages between understanding the voice of the customer, supplier quality, service quality, and ensuring customer satisfaction*

To identify the gaps and opportunities that compel recommendations for future research, these emerging trends from the most recent articles were contrasted with the themes detected in the *QMJ,* the patterns identified within the lists of the most influential articles, and the background provided by the association analysis.

GAPS AND OPPORTUNITIES FOR FUTURE RESEARCH

Several of the ideas that have been introduced in previous sections are compiled and synthesized here. The topics presented are not ranked in terms of their significance to researchers or practitioners, nor are they aligned along any dimensions of previously established frameworks for understanding quality management. This was a conscious choice to prevent unnecessary constraints on the recommendations, and intended to promote the novel and interdisciplinary expansion of quality management theory and practice as originally recommended by Ahire et al. (1995).

Validating quality management practices using contingency models

Network analysis and text mining results jointly indicate that quality management practices should continue to be validated in international settings, under different influences from the organizational culture, and in service quality environments. Some work has already been done to bridge the gap between theory development, organizational performance, and service quality in such cases. In particular, *QMJ* authors interested in this area should explore the recent contribution by Talib,

Raheman, and Qureshi (2010), which uses structural equation modeling on data gathered within the Indian service sector. This contribution is grounded in one of the top-ranked *QMJ* hubs, an empirical study by Prajogo and Brown (2004) that explored the relationship between TQM and quality performance in Australia. The most promising model for contingency studies appears to be Jabnoun et al. (2003), which is a top-ranked *QMJ* hub. As suggested by the authors, follow-on research should be done to empirically examine the utility of their contingency model across industries, for firms of different sizes and maturities. However, this is not the only contingency model available for quality management researchers to consider. Adam et al. (2008), for example, may provide additional background from which contingency research could be explored.

Information and knowledge management

Because two of the highest-ranked hubs focus on the software industry, this is a critical area in which researchers and practitioners alike should seek to explore the utility of various quality management practices. In addition, there is much opportunity associated with using information and knowledge management to better assess the voice of the customer, and to continually gather information to diagnose and improve customer satisfaction in an ongoing way.

Social media and collaborative supply chain

The patterns evident in the established and emerging trends suggest that there are some essential dynamics between identifying the voice of the customer, supplier and service quality, and customer satisfaction. Given this pattern, the presence of Finch's (1999) article in the list of *QMJ* authorities may indicate that technology mediated mechanisms, particularly those that involve the Internet, play a role. A more holistic investigation into service quality models, customer interaction, and customer satisfaction that includes customer interactions online may provide more sophisticated models for gathering voice of the customer data, ensuring customer satisfaction, and understanding the relationships between effective quality management practices and social media.

Social responsibility as a quality management practice

Although social responsibility has been part of the fabric of the Baldrige Criteria since the early 2000s, rigorous research into either what to do or how to do it following Ahire et al. (1995) is absent. Ascigil (2010) explored social responsibility in Turkish firms for the *QMJ,* but no broader examinations are yet available. Because the concept map indicates that *QMJ* research has effectively integrated strategy development and culture concerns into its examination of quality impacts of business results, hubs within the *QMJ* may provide an effective starting point (for example, Grandzol and Gershon 1997; Kujala and Lillrank 2004; Handfield et al. 1998; or Cameron and Sine 1999).

Interrelationships between quality management, organizational learning, and education

Although Senge's (1995) *The Fifth Discipline* appears on the most influential resources list in terms of its high PageRank score, and the Baldrige Criteria has always espoused organizational learning as a critical aspect of continuous improvement, there has not yet been a renaissance in the quality management literature that deeply explores the operational aspects of organizational learning. Furthermore, this theme has not been extended to the key interconnected concepts of supplier quality, service quality, and customer satisfaction. This is supported by the top-ranked hub article by Jabnoun et al. (2003), which emphasizes the importance of organizational learning, especially for organizations situated in very dynamic environments where the pace of change is rapid.

Integrating quality and innovation management

The concept of organizational ambidexterity has been linked to Six Sigma and TQM as a potential

mechanism for understanding how quality management and innovation management are related. Pursuing this research front would also provide the opportunity to advance recommendations by Sousa and Voss (2002) that are still valid, when identified that the theory on organizational change and learning could be leveraged much more strongly to understand how quality management practices could be applied in different environments, or even develop new approaches.

Impact of positive psychology on quality management practice

Although there has been recent popular interest in the impacts of positive emotions on enhancing quality and productivity (c.f. Johnston and Beck 2012; Schraeder and Jordan 2011; Crother-Laurin 2006) and a solid theoretical foundation for studying these concepts (for example, Seligman and Csikszentmihalyi 2000; Fredricksen 2001), quality management research has not yet addressed these areas. The current analysis indicates that *QMJ* has historically been strong in its coverage of quality culture, and how culture influences the achievement of business results, indicating that the *QMJ* community would be well positioned to explore this relationship in depth. However, there is no indication from this analysis that the topic has yet been pioneered.

IMPLICATIONS AND OVERALL CONCLUSIONS

Over nearly two decades, the *QMJ* has attempted to bridge the gap between the rigorous development of quality management theory and its practical application across various industries and contexts. The current study indicates that this goal has been largely accomplished, and that feedback between theory development and practice continues to be strong as the journal enters its third decade in print. The analysis indicates that *QMJ* has been particularly strong in its coverage of service quality, international aspects of quality management practice, and the role of quality culture as it relates to management, filling a significant gap first noted by Samson and Terziovski (1999).

The goals of this research were to identify the most influential resources leveraged by *QMJ* authors, identify the key established and emerging themes in the journal, and propose a research agenda for moving forward. These goals were accomplished by systematically evaluating the contributions made by *QMJ* authors through a variety of qualitative and quantitative methods, including a literature review of literature reviews, citation network analysis, and text mining and clustering. Readers can explore the top-20 lists presented within to find out which references have already been recognized for their far-reaching influence (see Table 4), which *QMJ* articles have been recognized for their broad and reliable coverage of a significant topic (see Table 5), and which resources overall can be considered the most broad and authoritative (see Table 6). These top-20 lists may also be useful for educators as they structure courses and curricula that include quality and operations management, in particular for selecting textbooks and readings that best capture the established contributions of the field as well as its emerging research fronts.

There are several managerial implications of this study as well. First and foremost, the continued need to examine quality management practices in light of contingency models underscores the importance for managers to be cautious and deliberate as they apply any quality management practice in a new context. In addition, the analysis reveals that since the global economic challenges of 2008, there is increased pressure to ensure that quality management practices result in desired performance outcomes. Researchers, similarly, should be sensitive to the changing demands on managers as a consequence of the shifting socio-economic context, and perhaps aim to clarify those further. This study also indicates that there are great potential opportunities associated with integrating concepts more deeply into quality management practice, such as new mechanisms for obtaining the voice of

the customer, positive psychology, organizational learning, and organizational ambidexterity.

Three primary emerging themes were noted in *QMJ* between 2009 and 2001: 1) teaching and learning in quality management, and quality management practice in education; 2) improving production quality through leadership and measurement of perceived quality along multiple dimensions; and 3) understanding the linkages between better understanding the voice of the customer, ensuring supplier quality, improving service quality, and achieving customer satisfaction. By combining these themes with gaps noted from other reviews, the following research fronts are identified as having high potential:

- Validating quality management practices using contingency models
- Social media and collaborative supply chain
- Customer information and knowledge management
- Social responsibility as a quality management practice
- Interrelationships between quality management, organizational learning, and education
- Integrating quality and innovation management, perhaps through Six Sigma
- Impact of positive psychology on quality management practice

Despite its contributions, this study has several limitations. The technique of filtering articles using centrality measures on a citation network is, by its nature, biased toward favoring older references, so more recent influential resources may not be detected. However, when a relatively recent article is emphasized as being influential using these methods, this is a strong indicator of the value of that reference. Any of the top 20 hubs that were published in 2003 and beyond, for example, should be noted as key articles that could be significant in the future development of quality theory or its evaluation in the context of empirical studies. For the analysis of emerging trends, examining the titles and key words using text analysis only provides an overview and is thus a primary limitation. Since differences were detected over the past three years of *QMJ* research using these cursory techniques though, a more complete text analysis of article abstracts may be even more revealing. Also, in the clustering portion of the analysis, only Euclidean distances were used to assess similarity and dissimilarity of terms. This may not be the most appropriate distance measurement, so similar studies should consider exploring other possibilities, such as the Mahalanobis distance.

Sousa and Voss (2002) also recommended that the continued development of quality management theory could be enhanced by more rigorous quantitative and qualitative data analysis methodologies. They suggested that researchers explore techniques such as structural equation modeling and causal network analysis of case study data. Results from the present study suggest that quality management researchers often apply case studies and factor analysis to draw conclusions from survey data (and to develop new valid and reliable instruments for assessment). However, it is uncommon to find research in quality management that features techniques beyond those that have traditionally been applied. There are likely to be substantial opportunities afforded to those researchers who seek to employ research methods that may be well established in other fields, but are new to quality management.

In conclusion, Ahire et al. (1995) first identified that quality management research and practice could be greatly catalyzed by *interdisciplinary* research teams, for example, to shift the study of customer satisfaction from the marketing domain to one that combined viewpoints from design, production, and supply chain management. To date, there have been no studies that examine the composition of teams who produce new insights in quality management, or explore the benefits that could be realized from conscious interdisciplinary or cross-disciplinary investigation of important issues in quality management. As the

field of quality management expands, the research community is encouraged, in addition, to strategically consider the benefits of creative alliances for exploring emerging issues of import to both researchers and practitioners.

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BIOGRAPHY

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APPENDIX A: CITATION NETWORK ANALYSIS METHODOLOGY

Overview

This appendix provides additional information about how citation network analysis was applied for this research to identify the most influential resources in the *QMJ* citation network using centrality measures. The procedures from this study can be broadly classified into three stages: 1) acquiring raw citation data from the ASQ Quality Information Center (QIC); 2) constructing the citation network (using Pajek, a network analysis software package); and 3) performing statistical and topological network analysis (using R, a statistical software package). Several algorithms from network analysis were selected to identify the most frequently cited resources, the most influential resources, and the concept map. This involved calculating four centrality measures for each of the articles within the citation network (degree centrality or number of incoming links k_{in}, Google PageRank, and Kleinberg's hub and authority scores) and rank ordering the values to identify the most influential references. These methodological approaches are summarized in Table A.1.

Table A.1 Summary of approaches used to generate results.

Result	Methodology/Algorithm Used
Most frequently cited resources	
Journal articles	Find maximum number of incoming citations (k_{in}) to articles within the network
Academic journals	Find maximum number of incoming citations (k_{in}) to journals within the network
Methodology references	Find maximum number of incoming citations (k_{in}) to articles within the network that mention research methodologies
Most influential resources	
Journal articles [1]	Google PageRank algorithm
Journal articles [2]	Kleinberg's authority score
Review articles	Kleinberg's hub score
Concept map	k-core decomposition

Data Acquisition

All 261 full-length articles that appeared in the *QMJ* between October 1993 and October 2008 were collected and used as source data. *QMJ* was selected because it is the only U.S.-based publication that is: a) solely focused on quality management, and

b) employs a double-blind peer review process to verify the integrity of submitted articles. If the study is to accurately characterize the discipline of quality management, it is critical to ensure that high-quality fact-based articles form the core of the network rather than opinion pieces. The data were gathered from the ASQ Quality Information Center (QIC), an online repository where the full texts of all back issues of the *QMJ* are archived. A total of 133 discussions, redactions to discussions, and dissertation abstracts that were also published in *QMJ* during this time period were not included, due to differences in the vetting criteria for these articles as compared to the full-length articles.

Incomplete references (where not enough information was specified by the author for another reader to find the source that was cited) were excluded from the analysis. All citations were standardized to American Psychological Association (APA) format for more effective data mining. Software programs were written in Perl to extract the citation information and relationships between nodes. A fuzzy search was used to avoid duplication of nodes, for example, when different editions of reference books were cited.

Network Construction

The *QMJ* citation network was constructed using the 261 articles and the 9,433 citations made by these articles, the *QMJ* citation network was constructed (see Figure 1). In a citation network, the nodes are journal articles, books, magazine articles, Web pages, television programs, personal communication, and so forth. Edges (or connections) in a citation network represent a flow of knowledge from an earlier source to the more recent publication. Original articles and references cited by the articles are nodes, and an edge is constructed from the original article to its reference to indicate a citation relationship. The result is a *directed network* in which a time dependence from A to B, where A has been published prior to B, is expected.

Mechanics of Network Analysis

The R statistical software was used to extract and examine the metrics characterizing the *QMJ* citation network. (R Development Core Team 2008) The `netmodels` package in R was employed to determine the basic topological characteristics of the network and compare it to equivalent random networks to confirm that there was organizing structure in the data. The `igraph` package was used to compute and compare four centrality scores for each of the 7,091 nodes in the citation network: degree centrality, Google PageRank, and Kleinberg's hub and authority scores. Pajek (Batagelj 2003) was used for network visualization.

To create a concept map of the articles in the *QMJ,* only the most influential resources were retained in a *k*-core decomposition, which was applied to the citation network so it could be inspected visually. This technique isolates the interrelatedness of the top-ranked articles at a more conceptual level by extracting the most central, connected components of a graph. (Alvarez-Hamelin et al. 2006) In a *k*-core decomposition, only the nodes with a degree centrality of *at least* k incoming degrees (or incoming citations) are retained. The three-core from the *QMJ* citation network, which was displayed in the main article as Figure 3 (with n=1,089), plots the size of each node in terms of its number of incoming citations. Larger nodes thus reflect greater degree centrality and greater popularity. In the original analysis the nodes were also assigned a color. Green nodes identified *QMJ* articles that appear in the top 20 using Kleinberg's authority score, blue nodes were *QMJ* articles that are not authorities, and yellow nodes were all non-*QMJ* articles that are not authorities.

Assumptions and Limitations

The citation network is assumed to be an *appropriate* model for knowledge flows, even though it cannot capture all of the knowledge flows within a field (for example, personal communication, email, or

other methods that are less formal than publications). The assumption was made for this study that it can still be considered representative of knowledge within the discipline, and thus appropriate for constructing concept maps (Zhuge 2006). The most critical assumption is that the information is complete, that is, the authors have appropriately cited all of the references that informed their research papers. Furthermore, this research assumes that there has been a sufficient quantity and diversity of reviewers, and that a double-blind peer review process was consistently applied (Hamacher 2008), meaning that the collection of articles is an objective representation of research progress within the discipline.

The primary limitation of this study is that the dataset only represents a subset of the full network of journal articles that have been published on the topic of quality management. The study is based only on the research published in the U.S.-based *QMJ* over the limited time period of 1993 to 2008. Thus, the results will not reflect the most central and influential resources in quality management, only those resources that have been emphasized by *QMJ* researchers. Even though many foreign researchers publish in the *QMJ,* this study may not adequately capture a global perspective on the topics of interest to both researchers and business.

There are additional limitations inherent in the sampling methods used to construct the network. For example, the network does not provide a complete view of the research in quality management because it does not include citation relationships between non-*QMJ* articles in the network. Adding these articles would reduce the values of all centrality measures while increasing the relative accuracy of the measures across the network. Despite this limitation, the study is subject to the same challenges as many other current analyses using the same methods (Stumpf 2005). The citation network extracted from the *QMJ* still provides a useful mathematical model for diagnosing the most influential resources and mining conceptual themes from the citation relationships.