The current issue and full text archive of this journal is available at
www.emeraldinsight.com/1741-0398.htm

A "genomic" classification scheme for supply chain management information systems

Tim S. McLaren
Faculty of Business, School of ITM, Ryerson University, Toronto, Canada, and
David C.H. Vuong
Queen's University, Toronto, Canada

Abstract

Purpose – This paper has the objective of demonstrating a more structured and useful method for evaluating functionality of enterprise software packages such as supply chain management information systems (SCM IS). Existing taxonomies have limited utility for software selection and analysis due to the variation and overlap in functionality found in modern enterprise systems.

Design/methodology/approach – A qualitative analysis of over 1,800 pages of SCM IS documentation and independent analyst reports is used to identify relevant SCM IS functional attributes in the seven most widespread SCM IS packages. Pattern matching and coding of constructs is used to iteratively build a hierarchical taxonomy of SCM IS functionality.

Findings – The taxonomy developed describes 83 major functional attributes that form five top-level categories: primary supply chain processes, data management, decision support, relationship management, and performance improvement. The codes representing supply chain processes agree with the widely used Supply Chain Operations Reference (SCOR) process model, although the terminology was not used consistently in vendor and analyst documents.

Research limitations/implications – The approach described enables richer classification schemes to be built that will better distinguish between the wide-ranging functionality found in modern enterprise information systems.

Practical implications – Selection and analysis of SCM IS is difficult due to the functional overlaps in different systems. The approach described enables a more structured, detailed, and useful analysis of an organization's current or proposed information systems.

Originality/value – This paper contributes a novel approach for conceptualizing and analyzing complex information systems using hierarchical rather than traditional flat taxonomies.

Keywords Fuzzy logic, Supply chain management, Information systems, Computer software

Paper type Research paper

Introduction

Supply chain management information systems (SCM IS) are an important e-business technology used for managing processes and coordinating information among the customers and suppliers of a supply chain. SCM IS are distinguished here from other enterprise systems in that they focus primarily on supply chain planning and execution rather than other functions such as human resources or accounting. Although SCM IS play an increasingly critical role in organizational effectiveness, few empirical studies exist that can offer guidance in their selection and implementation (Subramani, 2004). In order to understand the functionality provided by the various SCM IS packages available in the software marketplace, practitioners must sift through numerous specifications and reports created by software vendors, consultants,

Journal of Enterprise Information Management
Vol. 21 No. 4, 2008
pp. 409-423

1741-0398
DOI 10.1108/17410390810888688

or analysts. In this paper, we analyze over 300 such documents to build a hierarchical taxonomy useful for understanding and analyzing the functionality contained in large commercial SCM IS packages. The documents detail the functionality found in SCM IS software from the seven largest SCM IS vendors (by SCM IS revenue) which in 2004 included SAP, i2 Technologies, Manugistics, Oracle, PeopleSoft (recently acquired by Oracle), Manhattan Associates, and IBS (Reilly, 2005).

Wide variation in the functionality of different SCM IS makes analyzing and comparing systems difficult. Other attempts at classifying SCM IS have tended to group the various systems into clusters along one or two dimensions such as the breadth of functionality or nature of the interorganizational relationships supported (McLaren *et al.*, 2002; Kumar, 2001). However, such clustering approaches can only differentiate SCM IS at a very high level. It is also very difficult to cluster SCM IS into different categories due to overlapping functionality in most SCM IS and due to their tendency to be configured differently for each implementation (Helo and Szekely, 2005).

Rather than attempting to cluster various SCM IS along one or two dimensions as is done in a flat taxonomy, this paper develops a multifaceted hierarchical taxonomy to more accurately portray the rich functionality found in complex enterprise information systems. The approach is analogous to decomposing a human genome (DNA) into its composite genes. We seek to decompose the functionality of SCM IS into a hierarchical taxonomy (the "genome") which characterizes SCM IS according to the relative presence or absence of functional attributes (the "genes") in each software package.

This paper presents findings from a qualitative analysis of archival documents used to identify the relevant SCM IS functional attributes. A modified grounded theory approach was followed to help ensure the model constructs were derived from empirical descriptions of commercial SCM IS packages, rather than from purely theoretical constructs. The next section describes the conceptual foundations for the hierarchical taxonomy and the motivation for the study. The following sections describe the research methodology and findings from the analysis. The final section discusses the implications of the emergent model for research and practice.

Background

SCM IS are information systems (IS) used to coordinate information among the various customers, suppliers, and distributors in a supply chain. Traditional (flat) taxonomies would group SCM IS into categories such as electronic message-based systems, electronic procurement portals, or electronic marketplace systems (McLaren *et al.*, 2002). The problem with flat taxonomies is that most large SCM IS packages contain functionality that could fit into each of these categories. As a result, there is no clear way to distinguish between different SCM IS, which greatly impedes software evaluation and selection.

Developing a hierarchical taxonomy (genome) for supply chain management information systems enables a more precise description of different SCM IS and facilitates matching multifaceted functional requirements with the functionality offered by each system. The main drawback of a hierarchical taxonomy is the additional effort required to assess the functionality of SCM IS using dozens of attributes rather than one or two dimensions of a flat taxonomy. To mitigate the effort required this study demonstrates how qualitative analysis software tools can be used to help automate much of the analysis.

The goal of this research is to demonstrate a more structured and useful method for evaluating the functionality of complex software packages. Before any classification of SCM IS into their composite genes (functional attributes) can be done, we must first identify a parsimonious yet comprehensive set of SCM IS genes (the SCM IS genome). The specific research question addressed in this paper is: "What are the pertinent functional attributes that collectively characterize the range of popular supply chain management information system?" There are several motivations for developing a hierarchical taxonomy for SCM IS:

- Overlaps in functionality among different SCM IS prevent the development of useful taxonomies using the traditional approach of grouping products into different categories. This in turn makes the process of selecting appropriate SCM IS difficult as different packages provide different functionality and none of the packages provide all of the functionality of the collective population. However, by determining which set of attributes can best describe SCM IS systems collectively, we contribute a theoretical model that provides structure to the problem of SCM IS description, evaluation, and selection.
- The creation of hierarchical taxonomies using the metaphors of genomics has been demonstrated in successful commercial applications such as Pandora.com's Music Genome Project (Edlund, 2005). The genomics analogy would seem to be useful for describing detailed functionality of information systems, yet no peer-reviewed studies were found using this approach.
- The large volume of product descriptions, specifications, and analyst reports currently makes a detailed understanding of SCM IS functionality difficult. High-level reports do not detail specific functionality, which can only be gleaned by poring through hundreds of detailed specifications documents. In this paper, we use a grounded theory approach to analyze over 300 archival documents to identify the relevant SCM IS attributes.
- Different software vendors and analysts use different terminology to describe the same functions. Some terms are used interchangeably or inconsistently. For example, our analysis found some vendors use the terms "vendor-managed inventory" and "supplier-managed inventory" interchangeably, while others (correctly) distinguish between the two. To develop consistent definitions, the documents must be interpreted by knowledgeable readers to understand the latent meaning underlying each term. By interpreting and coding each document using a controlled vocabulary, we can, for example, distinguish between what should be classified as supplier-managed inventory and what should be vendor-managed inventory, irrespective of which term is used by the vendor.
- Using the hierarchical taxonomy, researchers and practitioners will be able to more accurately classify and describe SCM IS while providing greater detail on the functionality provided by specific SCM IS. A better understanding of which functionality is provided by which SCM IS software will enable organizations to evaluate and implement software that has a better match with their organizational requirements. Fuzzy logic may be employed to improve differentiation among SCM IS by enabling SCM IS to be classified according to the relative presence or absence of a gene (function). For example, one SCM IS may have highly sophisticated capacity planning functionality, while another

SCM IS might have limited capacity planning functionality. The rules for determining membership in a fuzzy set could be defined from existing and future empirical studies.

- The "best-of-breed" approach (implementing a portfolio of applications) taken by many organizations complicates the process of matching organizational requirements to software functionality (Light *et al.*, 2001). A hierarchical taxonomy for SCM IS would enable such matching to be done using fuzzy logic to determine the strongest matches between requirements and functionality where both sets have fuzzy membership. If an organization has organizational requirements that are not met by a single vendor's SCM IS, knowing the genetic makeup (functional attributes) of each SCM IS available would enable the organization to find the combination of SCM IS that best fulfill its requirements. The use of fuzzy sets enables the relative functionality of each SCM IS to be described in formal terms, which in turn facilitates development of computer algorithms and decision support systems to perform the fuzzy matching of organizational requirements and SCM IS functionality.

The remainder of this paper reports on research that identified the pertinent functional attributes in SCM IS. The analysis of which functions are present in specific SCM IS is outside of the scope of this paper. However, the hierarchical taxonomy described below enables such future research.

Research methodology

The goal of this study is to develop a theoretical model containing the functional characteristics that collectively describe SCM IS. To ensure that the model developed reflects an accurate description of the most widely-used SCM IS, a modified grounded theory approach was used. This approach ensures the model is grounded in empirical evidence rather than being built purely from theoretical constructs. Following a grounded theory approach (Strauss and Corbin, 1998), the study iterated between data collection, analysis, model building and model refining using evidence from the SCM IS literature. Proponents of the original Grounded Theory Method implied that theory could emerge from data independent of researcher bias. However, we acknowledge that the model has emerged from interpretation of the evidence and its meanings and have taken care to reduce researcher bias and triangulate findings where possible (Eisenhardt, 1989).

An initial literature review suggested several SCM IS functional attributes that could be incorporated into a comprehensive model of SCM IS "genes" (functional attributes). No peer-reviewed studies were found that encompassed the range of functionality in the most widely-used commercial SCM IS packages. In fact, no peer-reviewed studies were found that went into sufficient detail of the functionality of any commercial SCM IS package. Therefore, we conducted a qualitative analysis of 308 documents that described the functionality of the "Big Seven" SCM IS packages from SAP, i2 Technologies, Manugistics, Oracle, PeopleSoft, Manhattan Associates, and IBS. Since each vendor offers a portfolio of SCM IS applications, it is common practice to refer to the packages using the software vendor's company name rather than specific product names. These software packages represented the seven most popular (by market share) customizable off-the-shelf (COTS) SCM IS packages in 2004 who together accounted for approximately 40 percent of the SCM IS software market or over US$ 2 billion (Reilly, 2005). The median document size was about 1,500 words or six pages. The use of QSR's NVivo qualitative analysis software with its flexible content searching and coding tools greatly facilitated the analysis of the approximately 1,800 pages of text.

The lack of an existing theoretical model of SCM IS functional attributes prohibited the pre-specification of propositions and causal relationships, so an exploratory rather than confirmatory research approach was chosen (Lee, 1991; Eisenhardt, 1989). As different SCM IS vendors and analysts emphasize different functional attributes in their descriptions of the SCM IS, documents were collected from multiple SCM IS vendors. To maximize coverage of the research constructs while maintaining a manageable investigation, this initial study was limited to the seven most popular SCM IS packages. Although this ignores some specialized functionality in other niche SCM IS, limiting the scope to the "Big Seven" facilitated comparison and theoretical replication between the packages while reducing extraneous differences (Yin, 2003).

The approach taken was similar to using a multiple case study design for building theory from case study research. Since this grounded theory approach involved researcher interpretation, care was taken to use two researchers to code and interpret the documents in parallel, as well as to examine alternative interpretations of the passages (Klein and Myers, 1999; Eisenhardt, 1989). Researcher bias was also minimized by comparing the coding of one researcher who had significant experience working with and researching SCM IS with another researcher who had little prior experience with SCM IS. The experienced researcher contributed theoretical sensitivity in interpreting the documents and understanding the issues that arise from the evidence, while the naïve researcher was able to examine the same documents without being trapped in a pre-existing mindset (Strauss and Corbin, 1998).

Several sources of evidence were analyzed to determine the SCM IS "genes" that were pertinent to a descriptive model of SCM IS. These sources included software vendor documentation and research reports from independent analysts (see Table I). The selection of documents followed a "snowball" approach where additional documents were located as more details were required until "theoretical saturation" was reached (i.e. when additional analysis would add relatively little additional insight) (Miles and Huberman, 1994). The document collection started with the most popular SCM IS packages and hence more documents were analyzed for the more popular SCM IS than for the less popular packages. As in case study or grounded theory approaches, the documents were selected for relevance to the model rather than to be statistically representative of a population (Eisenhardt, 1989).

	i2	Manugistics	SAP	IBS	Oracle	Peoplesoft	Manhattan	Total
Vendor product documentation	54	34	17	10	68	21	20	224
Vendor case study report		18	59					77
Independent analyst research report	2	1	2		1	1		7
Total	56	53	78	10	69	22	20	308

Table I. Documents by source and product

In analyzing these sources of data, the researchers looked for corroboration of results and probed contradictions with further searches of the document database or by collecting additional data (Eisenhardt, 1989; Yin, 2003). For example, when it was discovered that SAP appeared to be the only vendor to distinguish between "vendor-managed inventory" and "supplier-managed inventory", additional evidence was collected to confirm this and to determine if the two terms were significantly different in meaning.

As with grounded theory or case study investigations, the findings from this study are intended to be "analytically generalizable" to a specific model of SCM IS functionality, rather than being statistically generalizable to other situations (Orlikowski, 1993; Yin, 2003). We do not claim that this model reflects any scientific truths or causal relationships. We have attempted to provide sufficient detail on the rigor of our approach so that readers may decide for themselves whether the findings are useful and could apply to SCM IS in general. An expert panel consisting of two management consultants each with over ten years experience in SCM IS implementation reviewed the emerging model prior to the creation of the final model. During this review, the panel identified several minor issues of interpretation that were subsequently recoded. Upon further review of the final version of the model, the experts both indicated the model appeared to be valid (*i.e.* to have good face validity).

The qualitative data analysis used pattern matching (Yin, 2003) and coding of constructs (Eisenhardt, 1989) to parse the archival documents for consistent patterns that were used to develop and revise the model of SCM IS functionality. While pattern matching was used to examine the emerging constructs, we did not pre-specify formal hypotheses. This was to retain theoretical flexibility and to better ensure the emergent theory is based on the empirical evidence rather than solely on the researchers' preconceptions (Eisenhardt, 1989). Following techniques from Strauss and Corbin's (1998) grounded theory approach, the document data were analyzed for recurring themes and patterns and coded into categories. The coding process iterated between open coding (unconstrained), axial coding (disaggregating), and selective coding (aggregating) phases. As new evidence was analyzed, constant comparison with the emerging categories was used to iteratively reorganize, expand, and collapse the categories until the model was sufficiently developed. The data gathering, analysis, and model building cycles were repeated until "theoretical saturation" was achieved – in other words, until further examination of the data did not reveal any further insight (Strauss and Corbin, 1998).

In coding our data, we used both manifest and latent content analyses. Manifest content is "the surface structure present in the message", while latent content is the underlying "deep structural meaning conveyed by the message" (Berg, 1998, p. 226). Since different vendors or analysts use different words to convey the same meaning or similar words to convey different meanings, both researchers coded the latent meaning of the words and resolved any disagreements in interpretation in order to arrive at a consistent model (Berg, 1998). Table II shows some examples of the codes and working definitions that were developed during the document analysis process.

The process of data collection and analysis and the findings were evaluated for trustworthiness or specifically, their validity, objectivity, and reliability (Kirk and Miller, 1986). Without triangulation with other research methods, it is difficult to

Table II. Examples of codes and working definitions from codebook

Code	Parent category	Working definition	Example passages	Coder comments
Available-to-promise (ATP)	Order processing	Support for determining if and when a potential sales order can be fulfilled from inventory or planned production	Manugistics enterprise profit optimization: "…identifying not only what is in inventory, but also what will be produced and available from a given supply of materials in inventory or production …"	Sometimes mistakenly labeled CTP. ATP checks existing inventory and production orders, but not whether there is unused capacity to create new production orders, which would be CTP
Capable-to-promise (CTP)	Order processing	Support for determining if and when a potential sales order could be fulfilled by creating a new production order using unused production capacity	SAP advanced planning and optimization: "… with these two functions, Freescale will be able to commit production capacity and available inventory to customers …"	CTP is differentiated from ATP here in that it checks available capacity, not just existing production orders
Procurement	Source process	Support for transactions used in acquiring goods or services but not including related management functions such as planning, reporting, and managing relationships	i2 Sourcing optimization: "The suite looks to combine product development, sourcing, supply planning, and procurement across the supply chain …"	It appears procurement should be a subset of the overall source process and be used narrowly to refer to transactional rather than decision-making support

evaluate the validity of the developed model, except to note that other supply chain experts consulted determined that the model appeared plausible (i.e. demonstrated face validity).

Objectivity refers to the chance that findings are based solely on the researcher's perceptions and biases. Objectivity was increased through parallel coding and analysis of the documents by the two researchers. Objectivity was also enhanced through triangulation of multiple data sources, constant comparisons and pattern matching between the emergent model and other data, and examination of alternative interpretations (Strauss and Corbin, 1998; Yin, 2003). Periodic coding reviews were performed to compare coding between the researchers and highlight any disagreements. Discrepancies were resolved through discussing the interpretations, searching for more evidence to resolve the discrepancies, refining definitions for the codes, and independently recoding the passages until the discrepancies were resolved. In several cases, initial disagreement on how to interpret a passage uncovered concepts that were used ambiguously in the practitioner literature. Resolving these ambiguities led to better-defined and delineated constructs.

Reliability in grounded theory studies is related to how easy it would be for another researcher to replicate the study and arrive at similar findings. Reliability was enhanced by using a formal document analysis protocol and maintaining a database of the evidence and findings (Yin, 2003). The use of QSR NVivo software facilitated the organization, coding, comparison, and analysis of electronic documents. At various times in the coding and analysis process, the coded NVivo database and emergent model was archived to maintain a "chain of evidence" leading from the coded document passages to the theoretical model (Miles and Huberman, 1994).

The following section describes the hierarchical taxonomy that has emerged from analysis of the documentation from vendors and independent analysts. These documents collectively describe the functionality contained in the top seven commercial SCM IS packages.

Findings

A grounded theory approach was used to identify pertinent SCM IS functional attributes and their hierarchical relationships (i.e. categories and sub-categories). Codes representing functional attributes were created by analyzing the text and identifying the latent concepts. At various times, the number of codes in the model approached 150. The final number of codes used was 83 as codes were merged if they were later found to be conceptually similar or if further analysis showed they were not significant functional attributes of SCM IS. For example, the codes "performance analysis" and "business intelligence" were each created during coding of separate documents. After coding all the documents in the database for these two codes and analyzing the coded passages, further analysis revealed there was little difference in the usage and meaning of these two concepts. Thus, passages coded as descriptions of "business intelligence" functionality were merged into those coded as "performance analysis" reducing the overall number of codes. The definition of the resulting code was then modified to include the concept of business intelligence. Similarly, some codes that were initially created such as "locate-to-order" were later omitted from the model when there was insufficient evidence from the other documents to conclude that this concept was important and distinct enough to retain in the model.

During the selective coding phase of data analysis, remaining codes and categories were evaluated using the grounded theory criteria of fit, distinctiveness, generality, and understandability (Strauss and Corbin, 1998). Codes and categories were retained if they fit the purpose of the model, were conceptually distinct from each other, were at an appropriate level of detail, and could be readily understood by other researchers. To help ensure each of these criteria was met, definitions of each of the codes were maintained in a codebook within the qualitative analysis software. Definitions and examples of each of the constructs are available from the authors.

The iterative model-building process results in an emergent model that can be further refined by further analysis or inclusion of additional documents. Theoretical saturation is obtained when the likelihood of new insight being obtained from further data collection and analysis is significantly diminished (Strauss and Corbin, 1998). This point was reached after several months of document collection, analysis, and coding resulted in the model shown in Figures 1-3.

Throughout the analysis we were reminded that different software vendors and analysts use different terminology to describe the same functions. The analysis helped resolve some of these inconsistencies by examining the latent meaning between the terms and creating singular definitions for the concepts. For example, some vendors used the terms "vendor-managed inventory" and "supplier-managed inventory" interchangeably, even though some practitioners distinguish between the two. We then examined the passages coded for these two attributes and found them to be distinct concepts. The following passages are from an analyst report on SAP's SCM IS from Faulkner's Advisory for IT Studies (Figueiredo, 2005):

> Supplier Managed Inventory (SMI) . . . support permits suppliers to check inventory status for their component parts across multiple plant sites, receive low-level alerts, and address such situations online.

> Vendor-Managed Inventory (VMI) . . . mySAP SCM offers built-in Web-based support for vendor-driven replenishment processes to boost stock utilization and customer service while keeping inventory levels low.

These passages support differentiating the two concepts because they appeared to refer to different techniques which require different SCM IS functionality – providing point-of-sale data to suppliers versus providing sales orders and forecasts. The open coding phase uncovered many similar conceptual ambiguities, which were resolved during the axial coding phase by examining the context and usage of the concepts to create more precise definitions.

During axial and selective coding, decisions were also made on how to best organize the model for describing the SCM IS functionality using various hierarchical relationships. We initially organized SCM IS functionality following the traditional delineation between supply chain planning versus supply chain execution (Barratt and Oliveira, 2001). However, it was often difficult to distinguish between planning and execution functions as the two are increasingly performed together when "real time" information processing is performed. Furthermore, since real-time optimization is a hallmark of SCM IS much of the functionality described in the documents would fit into the planning category, leaving much less to include in the execution category.

Analysis of the emerging top-level categories suggested that many of the codes fit the Level 1 process categories of "Plan, Source, Make, Deliver, and Return" defined by

Figure 1.
SCM IS functional attributes (with primary supply chain processes collapsed)

Figure 2.
Functional attributes for primary supply chain processes (with plan process group collapsed)

the widely used Supply Chain Operations Reference (SCOR) model (Supply-Chain Council Inc., 2005). Although the SCOR model is useful for organizing SCM IS functionality that supports primary supply chain processes, there were many functional attributes uncovered that did not belong in this grouping. These other attributes formed the other top-level categories in the model. Furthermore, since SCOR is a business process-centric model, it does not go into sufficient detail on what information systems functionality is required to support each of the processes.

At the highest level, the attributes were organized into five categories which represented functionality providing support for: primary supply chain processes, data management, decision support, relationship management, and performance improvement. Each of these categories describes a high-order functional attribute and also contains more detailed sub-categories or concepts. For example, both "scenario analysis" and "decision support" can be seen as a functional attributes of

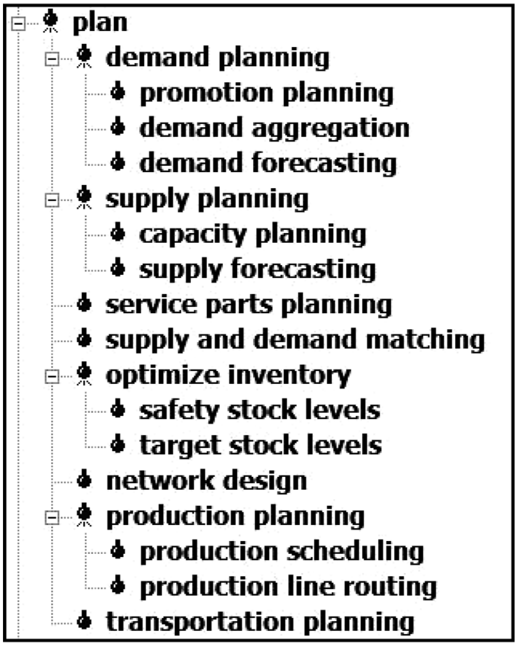

Figure 3.
Functional attributes for plan process group

SCM IS, even though "scenario analysis" belongs to the "decision support" category. The full set of 83 functional attributes is shown in Figures 1-3. Because these functional attributes emerged from a limited set of documentation and analyst reports (albeit over 1,500 pages of documentation), they are not intended to represent a complete taxonomic description that fully describe all SCM IS, or even full functionality of the seven largest SCM IS that were studied. Instead, these functional attributes should be viewed as the attributes that were most prominent in the most commonly used SCM IS applications. Future research could investigate more niche functionality as appropriate.

Conclusions and discussion

Previous attempts at classifying SCM IS generally group the systems into clusters along one or two dimensions. Such clustering approaches only provide high-level differentiation between SCM IS and have difficulty classifying today's highly configurable enterprise systems. Rather than attempting to classify SCM IS along two dimensions, we have developed a "genomic" classification approach using a hierarchical taxonomy which allows SCM IS to be characterized by the relative presence or absence of a set of functional attributes (or "genes"). The hierarchical nature of the model allows functions to be described in successive levels with up to 83 different functional attributes depending on the level of detail of the analysis.

A hierarchical taxonomy appears to be very useful for describing the detailed functionality of complex information systems, yet no peer-reviewed studies were found using this approach. We have described an approach for classifying SCM IS according to the relative presence or absence of various functional attributes (genes). The approach could be adapted for classifying other types of information systems or other entities that are difficult to classify into standard taxonomies due to complex, overlapping dimensions and attributes.

A qualitative analysis of vendor documentation and analyst research reports for the seven largest SCM IS packages was used to identify the functional attributes. The model of SCM IS functional attributes presented in Figures 1-3 is an initial conceptualization derived from empirical evidence. Although this initial model should be considered emergent rather than conclusive, it enables a more structured approach to software evaluation and selection and can readily be refined with analysis of further evidence. To limit the complexity and length of this paper, this study was limited to the seven most popular SCM IS packages and to analyzing vendor documentation and some analyst reports. Triangulation with additional vendor-neutral reports, published case studies, and new field studies would enable the model to further be refined and validated. Similarly, comparison of the functional attributes described in this model with functionality from niche SCM IS would also help establish the scope and applicability of this model.

We note that the organizational benefits of an information system often depend on how they are implemented and utilized in addition to what functional attributes they possess (Markus, 1983; Robey and Boudreau, 1999). However, by establishing a detailed model of SCM IS functionality, we enable future empirical studies that may compare designed functionality with organizational performance. Despite wide interest in SCM IS, few empirical studies examine their functionality in any detail (Subramani, 2004).

We also note the software evaluation and selection process involves examining much more than intended software functionality as described in vendor or analyst documents. Other decision criteria include prototype evaluations, vendor analyses, client references, site visits, etc. The preceding model is meant to demonstrate a novel way of conceptualizing enterprise software functionality and is not intended to serve as a complete software evaluation tool. Nonetheless, the hierarchical nature of the described taxonomy is particularly useful for enterprise software analysis and selection where the evaluation needs to be done at varying levels of detail from high-level functionality down to successively detailed levels. Sahay and Gupta (2003) describe one such evaluation approach using a weighted tree method for evaluating software using unbalanced hierarchical decision criteria (Sahay and Gupta, 2003). Although such hierarchical multi-dimensional software selection decision models are more complex than traditional models using a small number of dimensions, the software selection and analysis process could be made more useful and comprehensive using fuzzy logic-based decision support tools that could be developed in future studies.

Our analysis has led to the development of a model that enables a more detailed and precise understanding of the functionality of SCM IS. Using this genomic classification scheme, researchers and practitioners will be able to more accurately classify and describe SCM IS while providing greater detail on the functionality provided by specific SCM IS. This model also facilitates matching an organization's functional requirements with the functionality offered by a specific SCM IS package. Future research may also employ fuzzy logic to determine the relative presence or absence of a functional attribute in a specific SCM IS. This in turn, would enable development of computerized decision support systems for planning and analysis of SCM IS software selection and implementation.

In this paper, we have described an emergent model of SCM IS "genes" (functional attributes). The model creates a conceptual foundation for further research aimed at designing a more structured and useful approach to software evaluation and selection for highly modular enterprise information systems.

The purpose of this paper is not to provide a definitive evaluation of current SCM IS or to suggest that SCM IS can be evaluated solely on the basis of this model. Instead, we have demonstrated a novel approach for conceptualizing and analyzing highly modular information systems using analogies from the field of genomics research.

The model enables classification of SCM IS according to their "genetic composition" rather than by attempting to force SCM IS into different categories along a small number of dimensions. For practitioners, research in this area will be useful for selecting and evaluating modular enterprise systems and understanding their wide-ranging functionality. For researchers, this study contributes an empirically supported model of SCM IS functional attributes to the sparse but growing literature on supply chain management information systems. We have also described a novel approach to developing hierarchical taxonomies using the metaphors of genomics, which we see as having great potential for classifying complex multi-dimensional constructs that resist categorization using traditional (flat) taxonomies. The resulting model enables a more structured and useful approach to SCM IS software selection and evaluation. The purpose of this paper is not to provide a definitive evaluation of current SCM IS. Instead, we contribute a novel approach for conceptualizing and analyzing complex information systems using fuzzy set theory, qualitative analysis software, and hierarchical rather than flat taxonomies.

References

Barratt, M. and Oliveira, A. (2001), "Exploring the experiences of collaborative planning initiatives", *International Journal of Physical Distribution & Logistics Management*, Vol. 31 No. 4, pp. 266-89.

Berg, B.L. (1998), *Qualitative Research Methods for the Social Sciences*, Allyn & Bacon, Needham Heights, MA.

Edlund, M. (2005), "The Madonna Code: searching for the perfect music recommendation system", available at: www.slate.com/id/2121998

Eisenhardt, K.M. (1989), "Building theories from case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-50.

Figueiredo, D. (2005), "mySAP supply chain management", available at: www.faulkner.com/products/faulknerlibrary/ (accessed January 15, 2006).

Helo, P. and Szekely, B. (2005), "Logistics information systems: an analysis of software solutions for supply chain co-ordination", *Industrial Management & Data Systems*, Vol. 105 Nos 1/2, p. 5.

Kirk, J. and Miller, M.L. (1986), *Reliability and Validity in Qualitative Research*, Sage Publications, Newbury Park, CA.

Klein, H.K. and Myers, M.D. (1999), "A set of principles for conducting and evaluating interpretive field studies in information systems", *MIS Quarterly*, Vol. 23 No. 1, pp. 67-94.

Kumar, K. (2001), "Technologies for supporting supply chain management", *Communications of the ACM*, Vol. 44 No. 6, pp. 58-61.

Lee, A.S. (1991), "Integrating positivist and interpretive approaches to organizational research", *Organization Science*, Vol. 2 No. 4, pp. 342-65.

Light, B., Holland, C.P. and Wills, K. (2001), "ERP and best of breed: a comparative analysis", *Business Process Management*, Vol. 7 No. 3, pp. 216-24.

McLaren, T.S., Head, M.M. and Yuan, Y. (2002), "Supply chain collaboration alternatives: understanding the expected costs and benefits", *Internet Research: Electronic Networking, Applications and Policy*, Vol. 12 No. 4, pp. 348-64.

Markus, M.L. (1983), "Power, politics, and MIS implementation", *Communications of the ACM*, Vol. 26 No. 6, pp. 430-44.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*, Sage Publications, Thousand Oaks, CA.

Orlikowski, W.J. (1993), "CASE tools as organizational change: investigating incremental and radical changes in systems development", *MIS Quarterly*, Vol. 17 No. 3, pp. 309-40.

Reilly, K. (2005), "AMR Research releases supply chain market report showing 4% growth rate in 2004, reversing two years of decline", available at: www.amrpartners.com/Content/View.asp?pmillid = 18452 (accessed February 6, 2006).

Robey, D. and Boudreau, M. (1999), "Accounting for the contradictory organizational consequences of information technology: theoretical directions and methodological implications", *Information Systems Research*, Vol. 10 No. 2, pp. 167-85.

Sahay, B.S. and Gupta, A.K. (2003), "Development of software selection criteria for supply chain solutions", *Industrial Management & Data Systems*, Vol. 103 Nos 1/2, pp. 97-111.

Strauss, A. and Corbin, J. (1998), *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, Sage Publications, Thousand Oaks, CA.

Subramani, M. (2004), "How do suppliers benefit from information technology use in supply chain relationships?", *MIS Quarterly*, Vol. 28 No. 1, pp. 45-73.

Supply-Chain Council Inc. (2005), "Supply-chain operations reference model version 7.0", available at: www.supply-chain.org (accessed August 10, 2005).

Yin, R.K. (2003), *Case Study Research: Design and Methods*, Sage Publications, Beverly Hills, CA.

Further reading

US Department of Energy (2005), "The science behind the human genome project", available at: www.ornl.gov/sci/techresources/Human_Genome/project/info.shtml

Corresponding author

David C.H. Vuong can be contacted at: vuong.david@gmail.com