Allying for quality excellence: scope for expert systems in supplier quality management

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Abstract *Over the past decade, quality managers and scholars have focused increased attention on supplier quality as a key resource for organisations. This paper presents the results of an exploratory study into how organisations rank supplier selection attributes and the extent to which use is made of decision support systems (expert systems in particular) in supplier quality management. Overall, quality was ranked the most important attribute. Paradoxically, decision-support/knowledge-based systems are not being utilized in solving the multi-criteria decision problem inherent in supplier quality management. It is speculated that the lack of robust strategy for combining both human and artificial intelligence in supplier quality integration means that many organisations are making themselves vulnerable as out-sourcing and strategic partnerships become important determinants of competitive advantage. Consequently, this paper assesses the scope for expert systems, a branch of artificial intelligence that is capable of helping organisations to co-ordinate and harness potentially diverse sources of input resources in supplier quality management.*

Introduction

Supplier quality has a large and direct impact on the quality positioning of reseller organisations. The growing attention to this area of quality management reflects an understanding that a firm's quality performance (output) can only be as good as the quality performance of its suppliers (input) (Forker, 1999). This suggests an increasing tendency towards supplier development by organisations as supplier quality integration is found to be a critical dimension of quality excellence. Famous name UK retail organisations such as Marks & Spencer, Asda, and Tesco, to name a few, achieved success because of their tenacious zeal in enforcing strict quality standards on their suppliers. Thus, effective integration of suppliers into the reseller value chain is now seen as a key factor for achieving and maintaining superior quality positioning. As the strategy of supplier integration becomes more widespread, methods and criteria of their selection assumes a more critical dimension. Of equal importance is the strategic intelligence that underpins the evaluation of quality management processes implemented by suppliers and how it is facilitated.

The focus of this paper is on the development of supplier quality strategy linked to the primary activities, through procuring and using strategic

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resources, of an organization's value chain (Porter, 1985). Harland *et al.* (1999, p. 663) explain supply strategy as relating to the "integration of supply activities within the firm, in dyadic relationship, in chains of firms and their inter-organizational networks". Critically important in sustaining and gaining competitive advantage is the management of "different systems" levels of supply (Harland, 1996), the flow of supply and quality activities and decisions associated with that flow (Harland *et al.*, 1999; Handfield *et al.*, 1999).

Accordingly, what the recent years have witnessed is a growing body of literature on the role of effective supplier quality in altering the dynamics of competitive advantage and transforming business performance (Dorsch *et al.*, 1998; Forker, 1999). For example, the study by PIMS Associates reveals that pro-active, quality-driven supply strategy can add up to 4 per cent to sales value and 30 per cent to profitability (Thompson, 1996). This paper aims to achieve two objectives:

(1) identify the role of quality in evaluating and selecting suppliers and how this factor is ranked against others; and

(2) assess the level of adoption (and potential relevance) of expert systems technology in developing an effective supplier quality strategy.

The need to pursue this line of inquiry is legitimized largely because of the growing importance of information technology systems to yield sustainable competitive advantage through fostering organizational knowledge development and utilization (Lado and Zhang, 1998; Muller and Dyerson, 1999). Drucker (1990, p. 4) observed that a major challenge to any modern organization is the "integration of specialized knowledge into a common task". In the area of supplier quality, it makes sense to speculate on the potential role of expert systems (ES) in enhancing mutually rewarding relationships linking supplier value-adding activities to organizational competencies which, in turn, may lead to sustained competitive advantage.

Supplier quality management

Several studies (e.g. Flynn *et al.*, 1995) have found a positive correlation between quality management and quality performance. The study by the American Quality Foundation and Ernst & Young (1991) noted significant improvements in productivity, quality and profitability attendant upon TQM implementation. TQM, of course, is one of the most commonly cited quality management approaches. Paradoxically, the impact of supplier quality on quality performance of organisations has received limited attention (Forker, 1999). A great deal of what is known about this issue largely derives from anecdotal evidence as attention has been devoted more to the management of quality relative to finished goods than to supplier quality management (Trent and Monczka, 1999). This has resulted in diverse degrees of intelligence and learning among organisations in terms of the intangible supplier-related characteristics that directly impact on quality processes.

Gitlow and Wiesner (1988) suggest that supplier quality is influenced by two factors:

(1) internal organizational dynamics; and

(2) factors related to buyer-supplier relationships.

This dichotomy is analogous to assessments related to internal quality performance and external quality performance. Considering today's "wicked business environments" (Malhotra, 2001) and dynamic radical discontinuous change impacting on organizational performance, it seems logical to give a more integrative slant to the broad supplier quality management discourse. Although it has been argued that research studies on the impact of supplier quality on performance have yielded mixed results (Forker, 1999), it is nevertheless clear that supplier quality performance should be considered as part of a sound quality management practice, including TQM (Kanji and Yui, 1997). Addressing the issue of supplier quality requires an evaluation of the process(es) of supplier selection.

Supplier selection process

Since the seminal work by Dickson (1966), there have been incremental additions to knowledge relating to supplier selection and problems appertaining thereto. Some of the changes have encompassed an accelerated interest in quality issues, technical capabilities and improved computer communication (Weber *et al.*, 1991). However, little empirical research exists which addresses the actual selection stage involving the utilization of artificial intelligence-based information in making the choice of which supplier to select (Patton, 1996). Often, subjective measures are applied (Paulden, 1977; Hakansson and Wootz, 1975; Heinritz *et al.*, 1986; Weber, 1996; Cannon, 1998). The nature of the choice model to be adopted, according to Woodside and Moller (1992), is influenced by the number of suppliers from which a choice is to be made, the number of attributes, differences between suppliers, newness of the situation, technical/commercial importance of the situation, and time pressure.

Essentially, most market surveys (e.g. Griffith, 1998) indicate that organizations focus on four principal factors, namely, quality, performance, cost, and supplier service, in making selection decisions. However, the growing incidence of supplier switching has tended to further complicate the supplier-reseller relationship management (Nwankwo and Obidigbo, 1999). Often, the problem arises from suppliers' lack of focus on the intrinsic values of the reseller's business or a mismatch between suppliers' and resellers' quality systems.

Evidently, supplier selection and systems for facilitating a more integrative quality value chain are no longer taken as a rule-of-thumb activity. Increasingly, strategic perspectives are sought from the field of artificial intelligence (Nwankwo and Aiyeku, 2000). In the quest to enhance supplier development initiatives (Handfield *et al.*, 2000) and possibly overcome the

shortcoming associated with the traditional supplier selection techniques (Thompson, 1996), many researchers have gone further to apply decision support techniques. Examples include the data envelopment analysis (Weber, 1996; Liu *et al.*, 2000), analytical hierarchy process (Al-Faraj *et al.*, 1993), activity based costing approach, (Roodhooft and Koning, 1997), principal component analysis (Petroni and Braglia, 2000), and mixed-integer programming model (Kasilingam and Lee, 1996). Put together, the disparate approaches evident in the literature mirror a growing recognition that the use of coordinated strategic information and knowledge-based intelligence networks could fundamentally alter the dynamics of competitive advantage. Therefore, the recourse to the field of artificial intelligence for coping strategies is understandable.

Research methods

Two principal approaches were followed in the research process. The first involved a series of unstructured and informal one-to-one interviews with professionals in marketing (especially, the purchasing and supply functions). These interviews were conducted with 12 senior managers from a range of organizations in both manufacturing and service industries. Interviewees were chosen on discretionary grounds because of the knowledge and "privileged information" they possess based on the top hierarchical position they occupy in their organisations. Information obtained from the interviews afforded novel insights into a range of issues relating to supplier selection processes and problems, selection criteria and, very importantly, the scope for instigating quality standards among suppliers. The potential application of ES in carrying out these tasks was explored – each interviewee was given a demonstration of ES application in evaluating the financial capabilities of potential vendors. This method of inquiry enjoys support in the literature and is analogous to the "discovery-oriented" method (Deshpande, 1983) which has been utilized in other areas of quality management research (Morgan and Piercy, 1996; Nwankwo, 2000).

The second approach involved the distribution, through the postal system, of questionnaires to 500 UK organizations randomly selected from the COMPASS business directory covering the geographical areas of Lancashire, Lincolnshire and Yorkshire. Questionnaires were addressed to named individuals (where known), otherwise to the "purchasing manager". The questionnaire was intended to capture data on a range of issues including:

- how managers perform the task of supplier selection;
- the factors they consider in evaluating and selecting suppliers;
- the rank they allocate to those factors *vis-à-vis* quality; and
- the attitude towards the idea of using artificial intelligence systems to improve supplier quality.

Out of the 500 questionnaires sent, only 66 were duly completed and returned over a period of three months, achieving a response rate of 13.2 per cent. The response rate achieved is very low but typical of this type of research (i.e. postal surveys addressed to senior management positions with no pre-notification or follow up calls) and compares favourably with those of similar population and data collection methodologies both in the UK (Caruana, 1995) and USA (Dorsch *et al.*, 1998). For this reason, and being an exploratory study, no follow-up measures were undertaken to improve the response rate. However, the possible effect of non-response bias was investigated by comparing the response data from the early and late respondents (first and last quartile). This method is based on the assumption that late respondents are more similar to non-respondents (Armstrong and Overton, 1977). No significant differences were observed, thus indicating that non-response bias may not be a significant problem in this study. Overall, the limitations inherent in the research process cannot be underestimated. However, the severity is diminished when considered alongside its exploratory and discovery-oriented setting.

Results and discussion

Organizations that completed and returned the questionnaires were of different sizes and types. As a result, two sets of analysis were performed. The first was to determine whether the size of an organization influenced the way it selected its suppliers and the emphasis given to quality in the selection process. In this analysis, data collected enabled the grouping of organizations into five categories, based on the number of employees:

(1) 1 to 20 employees: 27.27 per cent;

(2) 21 to 50: 24.24 per cent;

(3) 51 to 200: 22.73 per cent;

(4) 210 to 1,000: 18.18 per cent; and

(5) over 1,000 employees: 7.58 per cent.

The second set of analysis was designed to ascertain how different organizations approached the supplier quality issue; that is, whether organizational type affected the way the problem is tackled. Five types of organization that completed and returned the questionnaire are categorised as follows:

(1) engineering companies: 45.5 per cent;

(2) process industries: 22.7 per cent;

(3) textiles: 7.6 per cent;

(4) printing and packaging: 10.6 per cent; and

(5) services: 13.6 per cent.

The number of employees in sampled organizations ranged from less than ten to over 1,000. The European Directives on business classification regarded

organizations with less than 200 employees as small to medium size enterprises (SMEs). However, given this range, common sense reminds us that intra-organizational contexts are likely to vary, for example, between those employing less than 20 and those with 50, 100 and 200 employees, hence the classification. It is pertinent to mention that the classification system applied is not intended to achieve any statistical regularity but simply a matter of curiosity. More so, it is expected that the more classifications or groups of an observation, the closer we get to reflecting or representing the real phenomena.

With regard to size, the majority of respondent organizations could be classified as small to medium size enterprises (SMEs). There are two possible explanations for this; either that the sample frame is overly populated by SMEs or the sample itself simply reflects the fact that about 90 per cent of all registered businesses in the UK are SMEs (Nwankwo, 2000). A 20-item rank factors (see Table I) was generated from the discovery-oriented survey. The idea was to subtly check the currency of Dickson's (1966) supplier attributes.

Respondents were required to rank the factors that they consider during the process of supplier selection. Ranks 1 to 20 were to be awarded, reflecting the importance they attached to each factor. For example, rank 1 indicated "most important" and 20 represented "least important". Where two or more factors were considered to be of equal importance and thus awarded the same rank, the next in rank will not have the next immediate rank. For example, if price (PRIZ) and quality (QLTY) were awarded rank 1, then the next immediate factor will have rank 3 instead of 2. This also implies that the affected factors will be awarded the mean average of the ranks (in this case, PRIZ and QLTY will have

Ranked attributes and abbreviations	Position
Quality (QLTY)	1
Price (PRIZ)	2
Delivery dates (DDTE)	3
After sales back-up (BKUP)	4
Technical competence (TKCE)	5
Honesty (HNST)	6
Manufacturing capacity (CPST)	7
Geographical location (GOLK)	8
Management efficiency (MGTE)	9
Provision of sufficient information (INFO)	10
Financial background (FNCE)	11
Conduct of sales representative (REPS)	12
Production methods (MTOD)	13
Reciprocal interest (INTR)	14
Position in the industry (PIND)	15
Recommendations (RCMN)	16
Similarity in technology (SMTK)	17
Size of organisation (SIZE)	18
Listing in the business directory (LSTD)	19
Loyalty to friend/relatives (LYTY)	20

Table I.
Position of ranked attributes – the global picture

a rank value of 1.5). The analysis used Spearman's rank order correlation to determine the level of correlation between the awarded ranks. Also, the Kruskal-Wallis test (Anderson *et al.*, 1988) was performed to assess the degree of variation in how organizations regarded the factors.

From the total usable sample, the average rank awarded to each factor was calculated and the factor that had the lowest ranked value was regarded as the most important. Table I shows the ranking.

As Table I reveals, quality, price, ability to deliver on time, production methods and the financial background of suppliers are respectively the five most important factors which organizations consider in making supplier selection decisions. On item by item rating, quality emerged as the most important criterion. This result is not surprising as it is consistent with those found in other studies (e.g. Dickson, 1966; Griffith, 1998).

Analysis by size

From this global ranking, it became necessary to find out whether the ranking would vary according to organizational size. Various patterns emerged (see Table II). There seems to be a significant level of correlation in how the ranks were awarded by different sizes of organization. However, there were other curious observations. The most curious were those relating to supplier quality (QLTY), Price (PRIX), as well as production methods (MTOD), financial background (FNCE), production capacity (CPST), firm's size (SIZE) and position in the industry (PIND). Using the one-way analysis of variance by

Factors	Size of organization 1-20	21-25	51-200	201-1,000	> 1,000
PRIZ	1	1	2	2	2
QLTY	2	3	1	1	1
DDTE	3	2	3	3	3
MTOD	13.5	12	13	8	8
FNCE	18	13	10	7	6.5
CPST	10	8	6	6	4
MGTE	7	14.5	8	5	5
TKCE	5	4	5	4	6.5
SMTK	19	18	16	14	15
SIZE	20	16	17	17	16
GOLK	6	7	7	13	12
PIND	16.5	17	14	16	11
REPS	8	9	11	15	18
HNST	11	5	9	11	10
BKUP	4	6	4	9	9
RCMN	12	14.5	18	18	17
LYTY	16.5	20	20	20	20
INFO	9	11	12	10	13
LSTD	13.5	19	19	19	19
INTR	15	10	15	12	14

Table II.
Rank position by organizational size

ranks, differences appeared in regard to, for example, QLTY and PRIZ. These appear to suggest that the larger the organization, the better the average rank given to quality than to other factors. By implication, larger organizations differ from SMEs in the degree to which they emphasized quality-related attributes in selecting suppliers. In contrast, SMEs are more likely than large organizations to base vendor selection decisions on cost considerations, recommendations from friends or colleagues, information supplied through brochures and loyalty driven by friendship or affinity. This result is understandable. Many large businesses have well-developed systems to collect and process information relating to supplier quality. Besides, the danger of destabilizing the quality value chain and/or consequences of supply disruptions is more far-reaching for large than small businesses. There may be other explanations from the field of organisation theory relating to management systems and structures – these are beyond the scope of this paper.

With regard to how supplier quality is measured, a variety of dimensions were emphasized and many organisations appear to apply different methods. However, six principal strands emerged:

(1) conformance;

(2) serviceability;

(3) reliability;

(4) durability;

(5) performance; and

(6) source credibility – perceived quality.

The overall primacy of attention accorded to quality by respondents did not appear surprising as the result is consistent with a host of previous studies (e.g. Gitlow and Wiesner, 1988; Griffith, 1998; Forker, 1999). A worrying phenomenon, however, is that emphasis seems to be placed on surrogate variables; that is, readily measurable parameters as against the value systems and philosophies which should embed a total quality orientation (Nwankwo, 2000). What is revealed, therefore, is that unless an organization is value-driven in its approach to quality management, its quality expectations are likely to be characterized by a standards-based rather than a culturally-ingrained perspective (Shadur, 1995). Evidently, a standards-based approach is desirable but not a sufficient proof of a quality orientation.

Analysis by type

A further ranking process was conducted based on organizational type by, first, working out the mean score for each ranked factor and, second, determining the ranking position accordingly. The ranking position is shown in Table III.

The degree of rank correlation, by organizational type, varied from modest to very high. An assessment of the extent of variation in the ranking, using

Ranked factor	Type of organization				
	Engineering	Process	Printing	Textile	Services
PRIZ	1	2	2	1	2
QLTY	2	1	1	2	1
DDTE	3	3	3	3	3
MTOD	12	11	11	20	10
FNCE	9	9	16.5	8.5	14
CPST	10	6	8	4	14
MGTE	8	7	13.5	11	8
TKCE	4	4	9	6.5	5
SMTK	16	18	18	20	16
SIZE	17	17	12	20	18
GOLK	6	12	4	8.5	12
PIND	15	16	19	20	17
REPS	14	10	10	10	6
HNST	7	8	7	6.5	7
BKUP	5	5	5	5	4
RCMN	18	14	13.5	20	19
LYTY	20	20	16.5	20	20
INFO	11	13	6	20	11
LSTD	19	19	20	20	14
INTR	13	15	15	20	14

Table III.
Rank position by organizational type

Friedman's two-way analysis of variance, indicates no overall significant difference in the way different types of organization ranked the attributes. On item-to-scale analysis, the only exception was RCMN that achieved a value of 9.57, higher than the table value of 9.488. Furthermore, using Kendall's coefficient of concordance, a value of 83.25 was obtained. This was then compared with the table figure of 36.19 at 0.01 with 99 degrees of freedom. The result confirmed that a set of factors matter irrespective of the type (or size) of organization. Essentially, all respondents agreed that price (PRIZ) and quality (QLTY) are more important factors than any other in selecting suppliers.

In business-to-business contexts, these results have a number of implications. As more and more organisations seek avenues for achieving the principles of business excellence (Russell, 1999), quality pressure will increase in an inverse proportion to cost – the classic notion of more (quality) for less (cost). Also, many firms will rely on fewer suppliers and become more involved in a closely coupled relationship in seeking quality excellence (Cannon and Perreault, 1999). For this relationship to endure, some of the major questions to which answers must be found include: which suppliers should be selected and on what basis? Is the supplier able to meet (and possibly exceed) an organisation's quality requirements? How might this be monitored on a continuous basis? Is the supplier quality roadmap aligned with that of the organisation? Therefore, it makes sense to characterise quality relationships between organisations and their suppliers in a manner that ensures that the quality value chain is "right the first time and always". Moreover, supply

quality integration involves a large number of variables and this is due to the multidimensionality of the quality concept itself (Gehani, 1993). Despite this, and the general acknowledgement of the growing difficulties in supplier quality management, a vast majority of respondents showed little awareness of, and disposition to use information technology-related/artificial intelligence systems now available and which could be usefully applied to improve decision making (see Table IV).

Awareness of ES

Intriguingly, the most ES aware respondents were found in service industries as against the textile sector that exhibited the least level of awareness. Perhaps, this is explainable. The nature of service organisations makes them more prone to "creative destruction" wrought by revolutionary changes in information technology than textile companies. Paradoxically, the textile industry in the UK is nearing extinction because of competitive onslaught from abroad. It is quite possible that one of the underlying reasons for the progressive decline of the sector lies in its aversion to adopting modern, leading-edge technological innovation in improving quality management. Curiously, however, the most ES aware groups (service organisations) are not the most enthusiastic to use the technology. A credible explanation may be found in the unique manner in which services are characterised. The distinctive characteristics of services (heterogeneity, intangibility, inseparability, perishability and the lack of ownership) may create a need for greater personal involvement in the management of quality.

Nevertheless, interest in the ES technology was evident among the respondents. After a demonstration was given to a controlled sample regarding ES capabilities in the financial assessment of vendors, observers became more favourably disposed to using the technology than before the demonstration. However, many admitted that they would need more information to be able fully to assess the operational advantages of the systems. Those who showed

	Awareness of ES (%)
Size (number of employees)	
Less than 20	15.8
20-50	29.4
51-200	40.0
201-1,000	16.7
Above 1,000	20.0
Type of organisation	
Engineering	21.21
Process	20.00
Printing and packaging	14.29
Textiles	00.01
Services	44.44

Table IV. Awareness ES by both size and type of organisation

willingness to use the system believed that its potential advantages could be more far-reaching than is already known. When the controlled sample was prompted, based on the prototype demonstration, to suggest possible advantages that the deployment of ES may yield in dealing with suppliers, the recurrent themes that emerged included:

- ease of processing multitudinous information;
- better decision making;
- increase in the quality and speed of decision making;
- simplified and easier means of selection;
- cost savings;
- effective monitoring of the supplier's quality base;
- means for quicker recognition of competent suppliers;
- the means for quicker identification of quality accredited suppliers; and
- the catalysts for a more efficient quality management.

Obviously, the complexities of supplier quality management in the evolving business environment are such that any system that supplements human intelligence is useful and worthy of deeper consideration. It is in this regard that expert systems offer an attractive proposition.

Expert systems: an overview and relevance to supplier quality management

Expert systems (ES) is a knowledge-based system within the field of artificial intelligence that focuses on leveraging human experts within organizations to gain competitive advantage. It does so by capturing the problem-solving knowledge of experts and making this information available to everyone in the organization. Once this knowledge is captured, ES can provide information on demand, 24 hours a day, to improve the effectiveness and efficiency of organizational decision-making processes of non-experts (Motiwalla and Fairfield-Sonn, 1998). Sometimes called "knowledge management" or "diagnostic systems", the systems use highly systematic, rules-based algorithms to approximate human knowledge and expertise in specialized areas. ES deals with problems the way a human expert does. In a very simplified form, its processes are as follows:

- eliciting specific experience and knowledge from human experts;
- coding the acquired knowledge into a computer readable form;
- storing the coded knowledge in a base; and
- consulting the knowledge base when required to solve specific problems or to offer advice on related issues.

Unlike conventional computer programmes, but quite like human experts, an expert system has the ability to justify its own line of reasoning in a manner

directly intelligible to the inquirer. A method used to attain this reasoning characteristic is known as rule-based programming. The rules are in the form of: IF ... THEN ..., i.e. IF <condition> and <(condition> and ...THEN <conclusion> and <conclusion> etc. Where all conditions and conclusions are statements with a truth value, the condition is called antecedent while the conclusion is the consequent, that is, IF <antecedent> THEN <consequent>. These rules can be used to construct powerful inference systems by being combined into networks in which the consequents of some rules (or parts of the consequent) are antecedents of other rules (or parts of those consequents); see, for example, Grandon (1996), Liker and Sindi (1997), Owrang and Grupe (1997), Proudlove *et al.*, (1998).

ES is being widely applied in the world of business, with positive impacts. Empirical evidence to this effect is available in areas such as accounting and risk management (Jablonoswki, 1997), insurance (Trencher, 1998), logistics management and business process reengineering, (Guimaraes *et al.*, 1997), human resources management (Grandon, 1996; Berry, 1997) and public service contexts (Berry *et al.*, 1998). Although there have been studies of the use of ES by businesses in the UK (Coakes and Merchant, 1996), no study, to the best of our knowledge, has related ES technology to supplier selection or supplier quality decisions in the UK. This is why this angle of inquiry needs to be further developed. However, there have been instances of the application of ES technology in other spheres of quality management. For example, Franz and Forster (1992) developed an ES decision support called total quality management systems (TQMS) to assist management in designing and developing an integrated TQM programme and strategy. Eom and Karathanos (1996) used ES to explore the improvement of management process in total quality management organisations. Also, Khan and Hafiz (1999) explored the development of ES for the implementation of ISO 9000 quality systems. Further evidence of successful application of ES to the quality management domain may be found in the following works: Evans and Lindsay (1987) on statistical quality control, Brink and Mahalingam (1990) on quality evaluation at the manufacturing level, and Eyada (1990) on ES-based auditing procedures of quality assurance of suppliers (see also Paladini, 2000). Thus, with the rich body of literature that is already available on the design of ES for quality management purposes, it was not considered necessary to elaborate its structural mechanisms and actual development for this particular paper. Moreover, work in that specific department is ongoing.

Implications

The primary thrust of this paper was to shed light, albeit in an exploratory manner, on the adoption (rather than the explication of design) of ES in relation to the overarching goal of "quality excellence management" through the integration of supplier and reseller quality value chains. Essentially, it was felt that the demonstrable capacity of ES to enhance organizational capabilities in the quality management arena, through "leveraging collective intellect"

(Junnarkar, 1997), would be of great interest to managers. Paradoxically, the general enthusiasm about this knowledge management system that was evident in the literature was not reflected in practical contexts – based on take up rates. Implicitly, a lot more understanding of management processes and market-based intelligence may be required in order to develop a comprehensive synthesis of the factors affecting ES' (or other artificial intelligence systems) deployment in supplier quality management. Given the present state of knowledge, the speculation that organizations would be spending about 20 per cent of their technology budget on ES at the turn of this century did not seem to have materialized.

A number of implications consequently arise from this exploratory study. Principally, although managers may be aware that adopting ES in supplier quality management may profoundly improve organizational quality performance, there are fundamental human-related barriers that should be overcome and which might become the important determinants of success in the deployment of the knowledge management technology. The most significant argument against the use of ES was the perception that the technology might undermine personal contacts and relationships. It was felt that personal contacts that enhance buyer-supplier relationship bonds are crucial for promoting closeness, trust, commitment, communications and reducing risks. Nevertheless, it seems clear that many of the reasons for the lukewarm attitude towards ES are not fundamentally different from those documented in the literature that explains why people use or refuse to use computer technology, especially in the area of management information and decision support systems (Berry, 1997). Therefore, in order to understand how ES may be usefully applied to achieve superior supplier quality performance, it is important to reflect and appreciate the processes that underlie sense-making actions of practicing managers. This could lead to the sort of intelligence that will help to enhance the rate of adoption of discontinuous innovation (including artificial intelligence, AI, systems), generally, in organizations. Consequently, those who are in the business of advising companies need to appreciate that there is a limit to the much-orchestrated AI revolution (Martin *et al.*, 1996). In the specific area of supplier quality management, there is a wide gap between rhetoric (ES' capability to deliver optimization-driven efficiency through conformance quality) and reality (lack of enthusiasm on the part of managers in using ES to integrate suppliers into their organizations' value chain – a core managerial activity that perceivably demands human overseeing).

To explore and establish this rhetoric-reality polarity, it is pertinent to highlight the distinction between sense-making and information-processing approaches to implanting IT-enabled knowledge management systems in general. The information processing approach, embedding ES, is analogous to a machine-based knowledge management system that assumes problems as given and solutions appertaining thereto are based upon a "preset algorithm" (Malhotra, 2001). This model is oriented towards error avoidance, nurtures conformance to rules and thus minimizes deviations from set standards

(conformance quality paradigm). The underlying thrust is that in dynamically evolving environments, characterized by intensely growing competition and uncertainty and where managers are confronted with a plethora of data for making quality management decisions, ES could fundamentally enhance firms' focus on optimization, efficiencies and economies of scale – leading to cost minimization and value maximization. This is a principal plank in arguments for AI-driven approach to quality excellence.

The sense-making approach is based on non-deterministic and context-specific nature of knowledge. Malhotra (2001) refers to this as the personal construction theory (a theory of meaning) that assumes a synergistic view of the rational and affective aspects of human intelligence. It essentially emphasizes the human and contingency nature of knowledge in contrast with the static representation of knowledge embedded in the information-processing model. If this model offers any explanation of the low level of ES application in the practical realm of supplier quality management, it is to show that managers do not concur with the proposition of knowledge as being embedded in computer-based databases, computer memories or programmed logic of inference (Malhotra, 2001, p. 13).

Thus, the recourse to the unprogrammed human processes for monitoring and evaluating supplier quality seems more profound than the programmed mechanistic processes. Perhaps Churchman (1971, p. 10) was right when he asserted that "knowledge resides in the user and not in the collection of information ... it is how the user reacts to a collection of information that matters". Based on this analysis, the proposition that emerges is that successful deployment of strategic resources (as in the case of using ES to manage supplier quality) may not so much depend on efficiency-enhancing capabilities of those resources but on sense-making processes of managers.

By and large, ES represents a part of the growing sophisticated competitive intelligence network pervading modern commercial life. ES-based knowledge management technologies could potentially deliver the right information to the right person at the right time, thus minimizing different subjective and possibly conflicting supplier quality monitoring and evaluation criteria. In this information age, coordinated and strategic information-related actions pose serious threats and, concomitantly, could become the important determinant of business success. As quoted in Eom and Karathanos (1996, p. 8), "without information and analysis, a company is blind, deaf and mute to the world around it; it will not be a competitor and will not survive the adverse business environment ...". In the field of supplier quality management, ES has enormous potential to help optimise organizational decisions and make the life of managers much easier. The system's uniqueness, among other things, in capturing myriad supplier quality-related activities and decisions that are important in helping an organisation to achieve a world-class quality positioning offers far-reaching advantages. Nevertheless, it may beg the question regarding the extent to which quality management systems that are based on simplistic assumptions about archived knowledge (in the form of

routinised programmable knowledge) could provide the basis to guide future actions, especially in the "wicked environments" that increasingly seem to defy the logic of pre-determination, prediction and pre-specification of information, control and performance (Malhotra, 2001, p. 7). Herein lies the greatest setback of any deterministic knowledge management device such as ES in managing the complex web of quality interfaces.

However, to be able to establish an integrative relationship between reseller organizations and their suppliers in a manner that is capable of delivering quality excellence, information-processing and sense-making approaches should be seen as being mutually reinforcing rather than mutually exclusive. There is no "one best way" to quality management. Essentially, the world of business is encountering not only unprecedented pace of change but also radical discontinuities in such change that makes "yesterday's proven rules of behaviour and models underlying such behaviours increasingly vulnerable" (Malhotra, 2001, p. 15).

Conclusions

It is hardly surprising that most companies find quality management to be one of the most demanding challenges they face – a challenge that the combined forces of globalization, the information revolution, more demanding customer expectations and increasing competitor agility has made even more difficult. In response to these forces, leading companies are adopting a new model of quality management based on supplier partnering. By doing so they recognize that suppliers are part of an extended, synchronized network of value-creating activities that span organizational boundaries from sourcing to consumption. An effective supplier quality strategy is, therefore, of considerable importance to many organizations as decisions relating to how input factors are sourced may greatly affect competitive positions. Interestingly, many organizations have in place well-developed systems for assessing product/service quality performance but rarely use equivalent methodologies in evaluating their own suppliers. Knowledge management such as offered by ES is an enabler and could serve as a key to the development of an integrated supplier quality strategy. However, a point needs to be made that ES will not replace human experts, but support their decisions. The objective is not to replace human thought but to augment it, and thereby assist humans to make better decisions that will, in turn, help make their organizations become the "best of the best".

In today's business world, the way in which supplier quality need to be perceived, structured and managed has changed remarkably. Effective integration and management of suppliers' value chain is central to a company's very competitiveness. The key to an effective supplier quality integration lies in creating competitive agility by building and managing scalable networks of suppliers that can work together to bolster a company's pursuit of quality excellence. By sharing knowledge and resources, such value networks are able to leverage their (suppliers') collective competencies into clearly targeted quality goals. In order to work effectively, quality value networks require the

emergence and utilization of electronically interconnected (AI-enabled) quality value chains in which partners have immediate access to the same information, and thus able to synchronize their actions in real time.

Supplier partnering for quality excellence is no longer a dream, AI knowledge management systems have made this a reality. Companies can use the power of ES to transform their suppliers' quality value chains. The growing utilization of ES by leading firms in the USA could not have happened without reasonable returns on investment. In view of the strategic value of ES, many forward-thinking organisations are likely to harness this technology to develop a comprehensive quality culture (Kanji and Yui, 1997). Organisations must recognize and accept several key truths about today's "semi-wired" world (Metz, 1998). The business environment is filled with turbulence, exacerbated by the growing impact of digital media on business processes. Success in the evolving environment, with all its attendant discontinuities, requires that management must come to terms with the inevitable knowledge-based, technology-driven transformations and determine how best they might be deployed to serve the quality needs of their organizations.

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