

## Developing global supply chain quality management systems

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This paper presents a global supply chain quality management (SCQM) framework as an extension of the traditional supply chain operations and quality management. Three distinct groups of variables are adopted in this study to illustrate the conceptual framework: a hierarchy of design variables, a hierarchy of system variables, and a hierarchy of problem solving methods. The aim of this theoretical framework is to offer practical guidelines to global business leaders and their value chain partners. This study also involves interviews with senior executives from a multinational enterprise in Taiwan. Four major SCQM themes are identified – design for six sigma (DFSS); international standards; supply chain management (SCM); global leadership and human resource management. In this study, we also view the cycle of decision making as an integral part of any global SCQM strategy. The analytic hierarchy process (AHP) is used to develop priority indices for the following three hierarchical levels: environmental scanning, strategic choice, and tactical choice. The presented framework adopts a systems approach and ensures that quality conscious products are designed, manufactured, and distributed.

**Keywords:** quality management; supply chain quality management; systems thinking; supply chains

### 1. Introduction

Achieving supply chain quality (SCQ) is not easy. A supply chain must undergo a transformation from its supply chain management approach to supply chain quality management. A typical supply chain network is fairly complicated. But, however complicated, as noted by Chow *et al.* (2008), Lambert (2004) and Madu and Kuei (2004), a supply chain can be implemented through nine elements:

- (1) sourcing,
- (2) supply chain relationship,
- (3) product development,
- (4) order fulfilment,
- (5) manufacturing,

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- (6) distribution,
- (7) customer engagement,
- (8) reverse logistics, and
- (9) Web-enabled platforms.

Madu and Kuei (2004) further note that supply chains exist for the purpose of connection, transaction, and delivery. They define supply chain management (SCM) with two simple equations, where each equation represents the letters that make up SCM. The definition is as follows:

*Supply chain:* A production-distribution network.

*Management:* Enabling conditions for integrity, integration, process optimisation, operational efficiency, continuous improvement, and sustainable competitive capabilities.

In the digital age, modern enterprises with supply networks need to develop strategic, technical, procedural, and organisational capabilities and capacities to respond to four emerging requirements: customer focus, technology adoption, relationships management, and leadership styles (Ogulin 2003). Figure 1 is a graphic depiction of a supply network and its managerial components.

Supply chain quality management (SCQM) is different from supply chain management (SCM). It is to create a sense of supply chain quality community. It is an extension of SCM that is designed to prepare firms to build supply chain competencies through tailored quality management practices (Madu and Kuei 2004, Kuei *et al.* 2008). In the early 2000s, Robinson and Malhotra (2005, p. 319) define SCQM as ‘the formal co-ordination and integration of business processes involving all partner organisations in the supply chain channel’. The aim of such a system is to ‘create value and achieve satisfaction of intermediate and final customers in the market place’ (Robinson and Malhotra 2005, p. 319). On that note, Kuei *et al.* (2008) showed that modern enterprises with supply networks need to design quality into supply chains, optimise the flow of materials, stabilise supply-chain-wide quality systems, and maximise the seamless sharing of data throughout enterprise resource planning (ERP) systems. Flynn and Flynn (2005, p. 3432) use survey results from 164 firms in the US and report that ‘organisations with stronger quality management practices achieved better supply chain performance’.

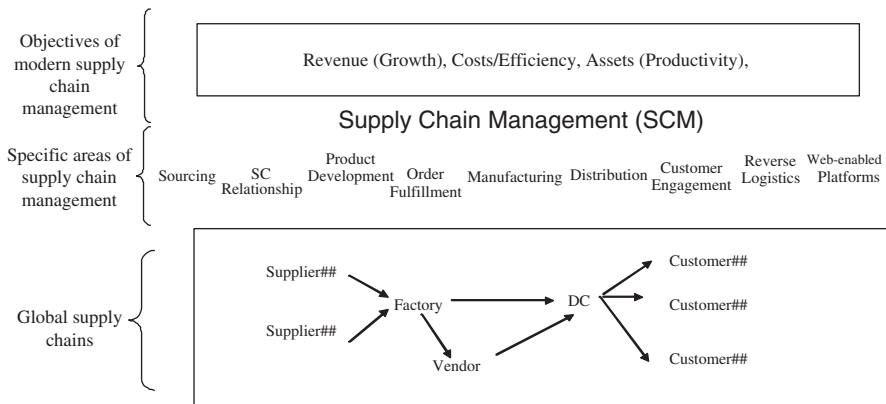


Figure 1. Supply chains and supply chain management.

They note that three key quality management practices were related to supply chain performance:

- (1) process management,
- (2) strategic planning, and
- (3) information and analysis.

Process management, for example, was related to global performance, volume flexibility, cycle time, and on-time delivery. Madu and Kuei (2004) also highlight the importance of enhancing cumulative capabilities along business processes to build a quality-driven supply chain. The ultimate success of supply networks is built upon value chain partners' capabilities to excel on all dimensions of supply chain quality. Lambert *et al.* (1998) further note that supply chain capabilities may be developed by focusing on two major areas: managerial and behavioural components, and physical and technical components. The former is characterised by elements such as leadership, management methods, risk and reward structure, and culture and attitude, while the latter regulates physical work flows, facility structure, and information platforms.

Based on 556 surveys collected in North America and Europe, Kannan and Tan (2005) demonstrated associations between SCQM factors and business performances. The competitiveness of firms, for example, appears to be correlated significantly with the following factors: strategic commitments to quality, supply chain integration and development, and information sharing. Market share and customer service seem to also be correlated with strategic commitments to quality. Kannan and Tan (2005) found that product quality is influenced positively by SCQM factors such as supply chain management (SCM) and total quality management (TQM). Casadesus and Castrao (2005) paint a somewhat mixed picture of the achievement of ISO 9000 certified firms in supply chains. Their empirical work, based on nearly four hundred ISO 9001:2000 certified firms in Spain, show that ISO can only pay off in three ways in a supply chain setting:

- (1) improving supplier relationships,
- (2) increasing customer satisfaction, and
- (3) reducing non-conformity costs.

However, ISO 9000 may not help much with respect to stock management, logistics costs, market share, and IT integration. Casadesus and Castrao (2005) thus encourage enterprises to adopt modern process change initiatives such as business process redesign and enterprise resource planning (ERP) systems. This suggestion is consistent with that of Madu and Kuei (2004). Kuei *et al.* (2008), through empirical studies, point out that multinational firms tend to focus on three areas with respect to supplier development: supplier participation, supplier/buyer trust, and supplier/buyer quality meeting. A similar notion is considered in Pyzdek (2003). As noted by Pyzdek (2003), with three sigma suppliers, it is not possible to reach six sigma quality levels. Through their structural equation analyses, Kanji and Wong (1999) also show that leadership drives the supply chain quality (SCQ) system that causes business excellence. SCQ systems in their study are comprised of four key components: customer focus, cooperative relationship, management by fact, and continuous improvement. Robinson and Malhotra (2005) identify two supply chain and quality management themes: internal supply chain and external supply chain. The emphasis of the former is placed on strategy, quality leadership, quality practices, and internally focused process integration and management, while the latter places a greater emphasis on communication and partnership, supply chain quality leadership, quality and

supply chain practices, and externally focused process integration, management and strategy. With this in mind, a multi-dimensional enterprise report was presented by Chang *et al.* (2008). This report outlines modern enterprise's capabilities in five areas: financial, customer, social commitment, internal process, and learning and growth. If performance improvement is to be achieved, Chang *et al.* (2008) note that modern enterprises need to pay attention to the following six issues:

- (1) board member participation,
- (2) departmental level alignment,
- (3) open presentation of results,
- (4) strategic budgets,
- (5) new information systems, and
- (6) evolving processes.

Despite this understanding and development in the areas of SCM and SCQM, many studies in the theoretical and descriptive literature fail to include theoretical paradigms of quality management in global supply networks and the linkages among components of SCQM systems. In the global economy, there must be guidelines to ensure that the SCQM system is better than the system being transformed. To fully appreciate the role quality plays in global supply networks and ensure the suitability, adequacy, and effectiveness of the modern SCQM systems, the following questions are explored in this study:

- How does globalisation of supply chain change the theoretical paradigms of quality management in supply networks? How should businesses respond to this change?
- What do recent advances in SCQM involve?
- Are there better ways for a multinational enterprise in the Asia-Pacific region to attain SCQ?

Global SCQM posits new challenges to the global economy. In order to survive in an unfavourable economic environment, modern enterprises with global supply chains must choose how to respond to the new reality in an effective way.

## 2. New challenges and pressures

Globalisation has presented new opportunities to modern enterprises with supply networks. Globalisation enables organisations of all sizes to access new markets, talents, capital, and technology, buy the best goods at the best prices, and develop global communities. The new opportunities are accompanied by new challenges of global SCQM. To grow and prosper in the twenty-first century, modern enterprises and their channel partners need to confront global challenges together. As shown in Figure 2, there are five main pressures affecting the functioning and quality of the global supply chain systems:

- (1) outsourcing,
- (2) protecting the environment,
- (3) reducing wastes,
- (4) developing communities, and
- (5) adopting advanced technologies.

These are now briefly discussed.

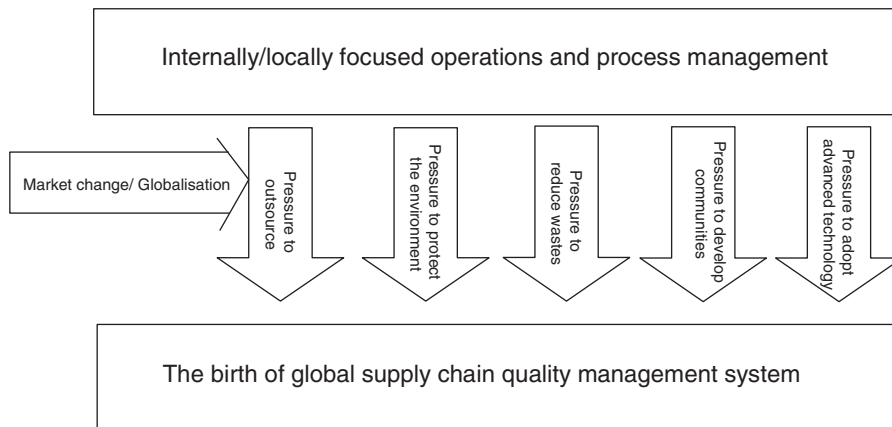


Figure 2. Linking traditional operations/process management to theoretical paradigms of quality management in supply chains.

### *Outsourcing*

In order to stay competitive in today's global market place, Burkholder (2006) notes that modern enterprises of all sizes generally have two options: choosing vertical integration or outsourcing. The downside of the first option, however (Burkholder 2006, pp. 227–228), includes:

- cut off from the outside world and possibly latest technology/market advances,
- diseconomies of scope, problems associated with managing a wide-range base of product- and process-engineering capabilities, and
- excess capacities and plant size imbalances.

As a result, outsourcing seems to be a viable option in the pursuit of supply chain success (Gadde and Hulthén 2009, Handley and Benton 2009, Lutz and Ritter 2009, Vivek *et al.* 2009, Kroes and Ghosh 2010). If implemented properly, it helps modern enterprises and supply networks to become efficient, reduce costs, have more capital to invest, and improve their productivity and competencies (Lutz and Ritter 2009, Kroes and Ghosh 2010). When outsourcing becomes the norm, a supply chain becomes even more complex and new challenges emerge. Outsourcing affects the purchasing aspect of manufacturers as well as the logistics parts of the merchants. Alongside the purchasing segment, Burkholder (2006) identified five important themes: partner relationship management, partnership objectives, supply infraction management, partner advocacy, and market intelligence. For the logistics segment, five critical factors are considered: process integration, consumer relationship management, demand management, fulfilment management, and multi-vendor interface management. To achieve this, Vivek *et al.* (2009) identifies two dominant relational governance stages:

- (1) Building calculative/non-economic trust.
- (2) Building dynamic capabilities through a trust-based relationship.

Handley and Benton (2009) use four survey constructs to unlock a business outsourcing process:

- (1) strategic evaluation,

- (2) contractual completeness,
- (3) relationship management, and
- (4) outsourcing performance.

Their empirical evidence shows that ‘outsourcing performance is significantly influenced by extensive strategic evaluation and proactive relationship management practices (Handley and Benton 2009, p. 344). Further, Gadde and Hulthén (2009) note a key challenge to logistics outsourcing is for enterprises to focus on four issues:

- (1) The decision about the scope of outsourcing.
- (2) The selection of the logistics service provider.
- (3) The development of the provider–buyer relationship.
- (4) The assessment of the outsourcing assessment.

#### *Protecting the environment*

Organisations with global supply bases are being put under pressure to strike a balance between development economics and sustainable economics (Zeng *et al.* 2003, Madu 2004, Zhu and Sarkis 2004, Zhu and Sarkis 2006, Zhu *et al.* 2007a, b, Lee and Klassen 2008, Zhu *et al.* 2008a, b, Feng and Ma 2009, Sarkis *et al.* 2010). Madu (2004) traced the origins of sustainable development to the United Nations publication in 1987 titled the Brundland report. The urgent need to live within environmental limits has since become abundantly clear. Trepant *et al.* (2008, p. 14) report that, according to a 2008 market research survey, ‘more than half of U.S. consumers take into account at least one sustainability factor, such as whether a product is organic or packaged in an environmentally friendly way’. This survey result provides further impetus for the modern enterprises to focus on sustainable operations initiatives. Feng and Ma (2009) also report the efforts made in a colour TV industry in China in the area of: materials purchasing, fleet operations, environmentally conscious manufacturing, energy use, field use, and product end-of-life management programs. Zhu *et al.* (2007a), using the Chinese automotive industry as an example, note that two major reasons affecting environmental sustainability are environmental burden and resource shortage. Madu (2004) also went further to discuss eight strategies for sustainable operations management: inverse manufacturing (closed-loop, end-of-product-life management), recycling, remanufacturing, reverse logistics (cradle to grave product management), eco-labelling, ISO 14000, life cycle assessment, and design for the environment. Launching sustainable operations initiatives across a complex global supply network is an ongoing challenge. Global enterprises of the twenty-first century priding themselves for the continuous efforts they are making to protect the environment need to face leadership challenges in global issues and the environment. Modern enterprises and their channel partners that fail to follow through may not be able to compete in today’s environmentally conscious market.

#### *Reducing wastes*

For supply chains not yet in a state of excellence, looking for waste avoidance or minimisation opportunities through reviews of waste generating processes is of paramount importance during the globalisation era (Madu 2004, Carreira 2005, Agarwal *et al.* 2006, Kainuma and Tawara 2006, Brown and O’Rourke 2007, Anand and Kodali 2008, Kurk and Eagan 2008). Seven specific types of waste are discussed by Carreira (2005):

- (1) over-production,
- (2) transport,

- (3) over-processing,
- (4) waiting,
- (5) unnecessary movement of products/people,
- (6) ineffective inventory control, and
- (7) activity and energy resulting from rejected products and inefficient processes.

To meet these waste avoidance or minimisation challenges, the organisation of concern must review its current operations practices and undergo a transformation process. Kurk and Eagan (2008) suggest that extensive strategic/tactical evaluation processes must be in place along the following product life-cycle stage: material selection, manufacturing, field use, transportation/packaging, and the end of product life. Madu (2004) identified five guiding principles for such a change.

First, people are the main drivers of process performance. Second, the key to enterprise intended performance is on processes. Third, leadership is essential. Fourth, there is no end in achieving continuous improvement. Finally, organisational performance must be measured and reported on a regular basis.

Adequate attention thus needs to be paid to how the process works and how the energy source is being used in supply networks today. Generally, many of the wastes that are incurred can be found in, or traced back to, core business processes, supporting processes, supply chain processes, and strategic planning processes. They need to be managed effectively. Along with this goes the belief that six sigma projects and concepts must be adopted in a supply chain setting for enterprises and their partner organisations to grasp them and build skills (Madu 2006). Zero waste can be enabled and realised by six sigma. Management must understand this new reality and take initiatives to reduce wastes.

#### *Developing communities*

Quality management in the traditional operations and process paradigm is built into all manufacturing processes but is usually focused on the finished product rather than developing communities. Competing in a new era of globalisation, modern enterprises should stimulate creativity and invest in good causes (Carroll 1991, Carroll 1999, Welford *et al.* 2007, Hutchins and Sutherland 2008). As noted by Hutchins and Sutherland (2008), for example, corporations today often face more intense pressure to respond to society's expectations. Hewlett-Packard, for example, offers education and entrepreneurship opportunities in underserved communities. To fulfil its promise, delivering responsible food for a sustainable future, McDonald's places greater emphasis on three areas: community, nutrition and well-being, and employee experience. Deere & Company makes similar efforts for developing communities. There is a greater focus on scholarship, diversity, community and philanthropy, and ergonomics and safe workplace. ExxonMobil, at the same time, places increasing emphasis on community development, international transparency, anti-corruption programmes, human rights, and work place (safety, health, and employment). These best-in-class corporations have one thing in common: they participate actively in their immediate environment in worthy causes, especially those of importance to the majority of stakeholders. As modern enterprises together with their channel partners demonstrate that they are reliable and dependable, they are valuable to the local and global communities. From the above business examples, it appears that strengthening communities through ethical and responsible behaviour is one of the themes emerging in this era of globalisation. Apart from business practices, there are some relevant management standards that deal with this challenge. Perhaps the best known standard is the Social Accountability 8000 standards (<http://www.sa-intl.org>).

One of the aims of this voluntary management guidance is to systematise the implementation of corporate social responsibility in global supply chains.

#### *Adopting advanced technology*

Advanced technology has an enormous effect on every aspect of supply networks (Madu and Kuei 2004, Bose *et al.* 2008, Jaruzelski and Dehoff 2008, Rachuri *et al.* 2008, Tarantilis *et al.* 2008, Daghfous and Barkhi 2009, Su and Yang 2010). Using a Chinese manufacturing organisation as an example, Bose *et al.* (2008) identify three key challenges in this domain: technical, China specific, and business process oriented. Through empirical study, Su and Yang (2010) confirm the operational, managerial, and strategic benefits of ERP for the SCM competencies. They also found that ‘more than 80% of respondents think it necessary to first adopt an ERP system as the backbone of company operations before deploying other enterprise systems (ES), such as the SCM system (Su and Yang 2010, p. 81)’. To facilitate effective decision making in meeting market demands correctly and achieving stakeholder satisfaction rapidly, modern enterprises and their channel partners need to identify technology applications that are consistent with the global progress and paradigm. A similar view was proposed by Rachuri *et al.* (2008) and Madu and Kuei (2004). Several cross-enterprise technology initiatives are thus worth noting: enterprise resource planning (ERP) systems, customer relationship management (CRM) and product lifecycle management (PLM). These advanced technologies have presented new opportunities to modern enterprises with supply networks. They enable organisations of all sizes to digitally connect all organisational units along supply chains, buy the best goods at the best prices, and develop supply chain overall competence. As noted by Jaruzelski and Dehoff (2008), however, modern enterprises today that differentiate their products not just by technology competence but also by their global innovation competence will have a greater impact on consumer choices and business performance. Specifically, Jaruzelski and Dehoff (2008, p. 58) note that companies that:

- deploy 60% or more of their R&D outside their home countries tend to outperform their less-global peers, and
- invest a higher percentage of R&D resources than sales abroad also outperform others.

To all those enterprises in favour of global progress, the report by Jaruzelski and Dehoff (2008) echoes another round of new challenges and pressures in the years to come.

### **3. The birth of the global SCQM system**

We have examined the current context surrounding today’s global progress. The impact of globalisation on the development of today’s SCQM has been profound. Once global supply chain managers embrace the concept that global SCQM could make a difference in a global supply chain setting, and that the entire global SCQ system could be managed and/or designed better, they would have to plan implementation strategies to realise the full potential of global SCQM. Figure 3(a) depicts two paths toward this. To meet the new challenges of quality in global supply chains, as can be seen in Figure 3(a), the first path is to adopt a learning framework such as EFQM excellence model (<http://ww1.efqm.org/en/>). The EFQM excellence model includes two elements: enablers (leadership, people, strategy, partnership and resources, processes/products/services), and outputs and outcomes (people



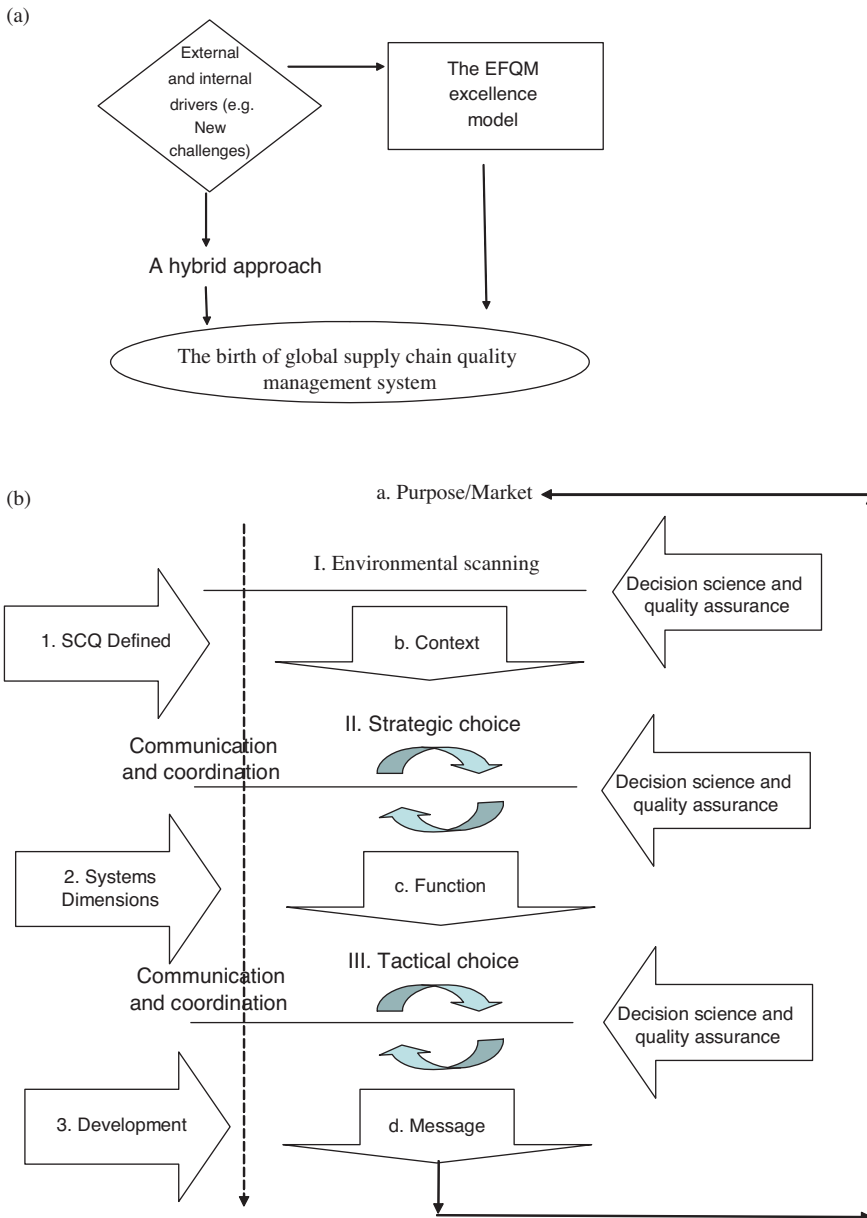


Figure 3. (a) The birth of global supply chain quality management system. (b) The architecture of our hybrid approach.

results, customer results, society results, key results). This model can be extended to address specific quality concerns in a global supply network. When formulating business strategies under uncertainty, however, as noted by Li and Li (2009, p. 5558), ‘it is evident that many directors or senior managers lack knowledge and analytical skills’. To deal with this, it is important to consider another path for both policy deployment and strategy formulation.

Thus, another goal of this study is to present the ideas, concepts, and methods of decision analyses in the context of global SCQM. A hybrid approach is thus adopted to help decision makers design a complex global SCQM system, spot strategic/tactical problems early, and develop plans to better serve the stakeholders (see Figure 3(b)). As shown in Figure 3(b), the architecture of the hybrid approach, global SCQM is a complex meta-system which effectively subsumes a whole range of critical components, including design (purpose/market, context, function, and message), system (SCQ defined, systems dimensions, and development), and decision (environmental scanning, strategic choice, and tactical choice). Practices such as communication and coordination are considered as integral parts of our proposed global SCQM system. Global supply networks today must change to embrace the new focus on supply chain quality. The architecture and high level design outlined in Figure 3(b) must be adopted to effectively set the stage for the implementation of global SCQM systems. We shall examine the conceptualisation of each of the dimensions briefly.

#### *Design components*

Salustri and Eng (2007, p. 22) state that 'one designs to cause an eventuality'. This can be done through devising 'courses of action aimed at changing existing situations into preferred ones (Salustri and Eng 2007, p. 19)'. In the man-made world, as noted by English (2007, p. 21), designers must specify:

- (1) The purpose of the system in question – why do we want it?
- (2) The market place – who is it for?
- (3) The context of use – how does it fit in?
- (4) Function – what does it do?
- (5) Message – what does it say?

These five constructs are adopted here to frame the design space of our proposed global SCQM systems.

Purposeful global supply networks must have an explanation for their existence. If a supply network has no mission or goal, there will be no clear direction to follow. Global supply networks with purpose are more focused and can target the right markets for system design, product introduction, channel development, and performance improvement. Global supply networks are in business to satisfy a particular market niche. In the new world of abundant choices, products are designed on customer demands and at prices the customer wants. This poses new challenges to modern enterprises with global partners. From a modern enterprise perspective, it needs to have a high level of contextual understanding from the physical domain of global supply networks to the managerial and behavioural domain. Value chain partners at the same time need to share consistent information, plan ahead, and respond timely, proactively and profitably to new markets, new methods, and the new technology breakthroughs. What they need collectively are critical market and product information, overall cost structures, quality and environmental guidelines, and channel development strategies. Market demands and functional requirements further form the foundation of function (i.e. what does it do?). Global supply chain teams as a result need to specify quality dimensions that cover a whole range of customer requirement issues. They also have to ensure that functional specifications can be actually executed and functional requirements with respect to intended system behaviours are actually met. Along with this goes the design that SCQ metrics adopted by modern enterprises must be relevant for value partners to grasp them

and build skills with. In light of the complexity and hardships being faced by many multinational businesses today, supply chain designers and managers need to take extraordinary leadership efforts and measures to improve the design space of a global SCQM system. How this, from the purpose to functions, can be best communicated and coordinated is the issue at hand in the global context. Madu and Kuei (2004) provide detailed discussions on this.

#### *System components*

Gharajedaghi (2006) notes that paradigm shift can happen purposefully. Whether or not such a paradigm is present, however, depends upon other surrounding circumstances such as the components of global SCQM system and the cycle of decision making. In order to compel system and project investments, modern enterprises with global supply networks need to focus on three system components: the definition of SCQ, system dimensions, and system developments.

In order to gain understanding of SCQM systems, we first need to focus on the definition of SCQ. We shall use the nine specific areas of SCM shown in Figure 1 to accomplish such a task:

- (1) Sourcing quality (Madu and Kuei 2004, Gadde and Hulthén 2009): Supplier capability, supplier quality, supplier–buyer relationship, procurement and inventory accuracy, transportation quality and delivery reliability.
- (2) Supplier relationship quality (Fynes *et al.* 2005, Vivek *et al.* 2009) (calculative/non-economic): Trust, adaptation, communication and co-operation.
- (3) Product development quality (Madu and Kuei 2004, Rachuri *et al.* 2008): Concept design, prototype testing and detail design.
- (4) Order fulfilment process quality (Forslund 2007): Promised lead time, on-time delivery, rush orders (when needed), stock-out rate, undamaged deliveries, accurate orders, accurate invoices, availability of delay information, and convenient order placement procedures.
- (5) Manufacturing quality (Garvin 1991): Performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality.
- (6) Distribution quality (Mentzer *et al.* 2001): Personal contact quality, order release quantities, information quality, ordering procedures, order accuracy, order condition, order quality, order discrepancy handling and timeliness.
- (7) Customer relationship quality (Berry and Parasuraman 1991): Reliability, responsiveness, assurance, empathy, and tangibles.
- (8) Reverse logistics quality (Madu 2004): Reduce, recycle, reuse, and disposal
- (9) E-quality (Madu and Madu 2003): Aesthetics, information content, accessibility, performance, serviceability, features, dependability, purpose, usability, capability, and timeline.

The concept of system dimensions also applies to the explanation of how multinational enterprises develop their global SCQM system. System dimension in this context is composed of five elements:

- (1) Channel and membership planning.
- (2) Physical network configuration.
- (3) Governance/ethics/conflict management.
- (4) Technology platforms.
- (5) Supply chain (SC) throughput processes.

System dimension frequently takes the form of hierarchy. As noted by Gigch (1978, p. 375): 'Hierarchy implies a framework that permits complex systems to be built from simpler ones. In turn, the existence of a hierarchy allows complex systems to be broken into their component parts and subsystems.' Hierarchy as a result provides new ways of thinking about global SC hierarchical structures and hierarchical arrangements. It helps us 'to organise, to understand, to communicate, and to know about complexity (Gigch 1978, p. 375)'. Unraveling global SC complexity thus involves trying to understand and target the natural forms (i.e. hierarchical structures) and schemes of SC contrived by modern enterprises (i.e. hierarchical arrangements). In a global socio-cultural environment, modern enterprises with global supply networks need to understand the science of complexity, recognise the existence of a SC hierarchy, restructure themselves if needed, and handle interdependent sets of variables in order to address strategic and tactical SC problems and concerns.

It must, however, be mentioned that global SCQM implementation cannot be successful without another system component, that is, system developments. Its major roles in this context can be described as realisation and further developments. The former, as noted by Gharajedaghi (2006), refers to behaviour realisation (rational, emotional, cultural), functional realisation (technical, product, market, operations, leadership), and structural realisation (legal, components). The latter refers to competence developments with respect to the physical content of jobs, the mental content of jobs, and the information content of jobs (Gigch 1978). Integration and co-ordination is the key to success here. When the business units along a global supply chain are fully integrated and well co-ordinated, they have capacities to comprehend causality, absorb newly acquired information from fragmented markets, address unacknowledged angst, make quicker decisions, and respond timely to the changing environment. When the elements of system developments are adequately managed, the modern enterprise becomes competitive.

#### *Decision components*

In a typical global supply network setting, the feasibility of any quality efforts begins with enterprise's alliance with its value chain partners. Effective communication among partners should be stressed and barriers that limit such communication should be broken. Typically supply chain managers use a variety of ways to describe and communicate their plans and solution strategies. In this study, we recommend using a decision making approach as a vehicle for the communication of real ideas. Kaplan and Norton (2008, p. 63) also note that, 'successful strategy execution has two basic rules: understand the management cycle that links strategy and operations, and know what tools to apply at each stage of the cycle'. As decision makers in a multinational enterprise consider their strategic and operational plans, they also need to have the ability to frame problems and identify the solution space. Generally, global SCQ problems can be arranged according to three distinct hierarchical levels:

- (1) *Environmental scanning*: The understanding of situations in global problem scenarios.
- (2) *Strategic problems*: Decisions about channel and membership development strategies.
- (3) *Tactical problems*: Decisions about planning SC activities to meet market demands and/or SCQ development strategies.

Modern enterprises should solicit and hold meetings with their channel partners to identify problems along the cycle of SCQ decision making before developing corrective measures. To prepare and focus practising managers' creative abilities on how each function (along three hierarchical levels) might behave in realising the full potential of SC systems, a variety of decision making tools are discussed by Madu and Kuei (2004), Saaty (2005), Madu (2006) and Saaty and Vargas (2006). They are the analytic hierarchy process (AHP), the analytic network process (ANP), quality function deployment (QFD) packages, and six sigma methodologies. The 'how' part resulting from the solution space discussed here is crucial to high level SCQM performance.

We have suggested throughout this entire section that 'SCQM systems as a method of responsible change under new global pressures' has an important role to play in our global society. The implementation process presented here, however, is generic and does not relate to any specific global supply networks. It is a systematic procedure that has to be taken irrespective of the supply network in the global context. For the purpose of this study, we shall use a case study to further describe the decision component of our proposed SCQM framework.

#### **4. The multinational business case in point**

One of the objectives of this study is to follow through the decision cycle of our proposed hybrid approach. As an example, we consider a Taiwan-based computer and electronic home appliance manufacturer. Its global subsidiaries include Taiwan (headquarters), China, Japan, Thailand, Singapore, Vietnam, USA, Canada, Mexico, United Kingdom, Czech Republic and the Netherlands. It makes full use of the supply of key components from its subsidiaries located in China. The ultimate goal of its global supply network is to minimise cost, increase speed of product delivery, and improve the quality of service. EMBA (executive MBA) students from one of Taiwan's major universities were invited to participate in this case study. The AHP is the tool used to solicit information from participants along three hierarchical levels discussed before (i.e. environmental scanning, strategic problems and choice, and tactical problems and choice). In theory and practices, numerous decision science models exist that can aid in global SCQM. Here are some reasons why we choose the AHP approach.

- (1) It allows a systemic consideration of the problem by identifying all the important tangible and intangible factors.
- (2) It allows for the use of key stakeholders in the decision-making process. This is the decision-making situation normally found in the case of Global SCQM.
- (3) It helps to breakdown a complex problem into a decision hierarchy. AHP decomposes decision and policy-oriented problems in a hierarchical structure (see, for example, Figure 4(a)).
- (4) It helps to structure discussions and allows for an analytic process of finding solutions. It depends on decision makers' subjective judgment in the process AHP evaluation. This is based on a pairwise comparison of items by using a nine-point scale to assign the decision makers' judgment (see Appendix 1).
- (5) It helps to estimate the relative importance weights of the various factors on an overall objective. A decision support system called Super Decisions' can be used for obtaining priority weights. Saaty (1980, 2005) developed the methodology underlying Super Decisions.

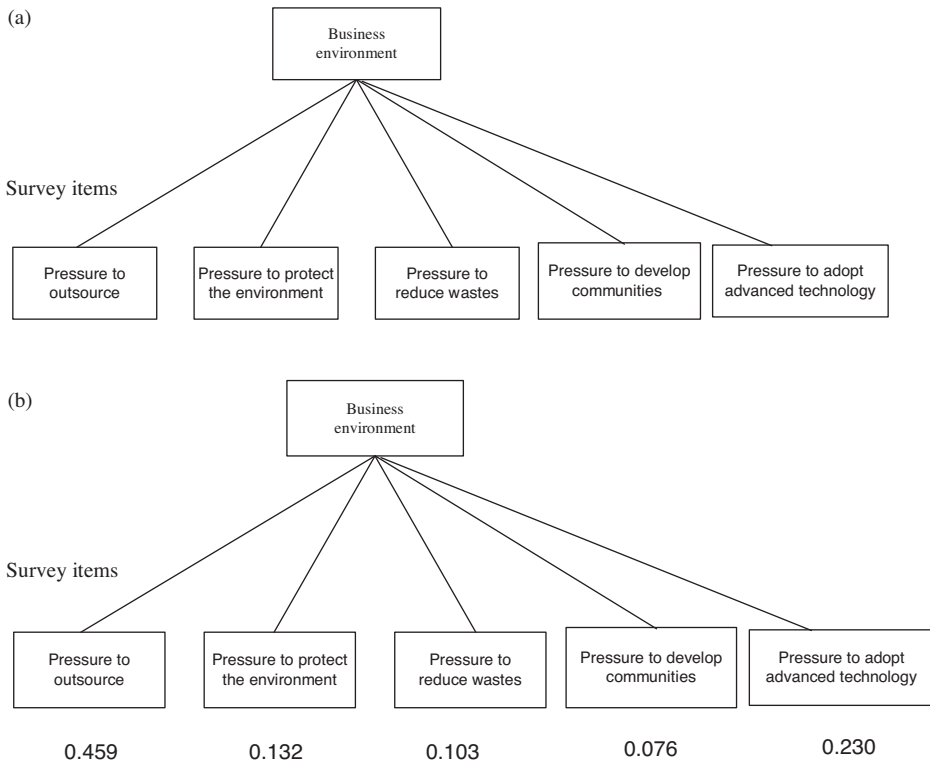


Figure 4. (a) AHP hierarchy – environment scanning. (b) Results – environment scanning.

- (6) Its application may facilitate the acceptance of the final outcome by members of key stakeholders.

Interviews with the corporate executives were also conducted to verify the strategic direction of our multinational enterprise in question. An affinity diagram is constructed at the conclusion of our interviews.

**4.1 Environmental scanning with the AHP/affinity diagram**

The analytic hierarchy process (AHP) is a multi-criteria, multi-level decision model that develops priority weights for items based on decision makers’ professional evaluation (Saaty 1980, Madu *et al.* 2002, Madu and Kuei 2004, Saaty 2005, Saaty and Vargas 2006, Goncu and Bayazit 2007, Rabelo *et al.* 2007, Kuei *et al.* 2009, Sueyoshi *et al.* 2009, Yang *et al.* 2009). Goncu and Bayazit (2007) use the AHP model for predicting the fashion trends of 2006–2007 suitable for target groups of young consumers. Decision-making criteria are selected for determining the trends of styles and fabrics categories in the fashion business. Kuei *et al.* (2009) also adopt the AHP way to verify the importance of environmental initiatives for realising the triple line concept (i.e. social development, environmental protection, and economic development) in Taiwan. For the purpose of this study, we also adopt the AHP to evaluate five main pressures discussed

earlier: outsourcing, protecting the environment, reducing wastes, developing communities, and adopting advanced technologies.

A systematic approach consisting of four steps is adopted here:

- (1) Building a hierarchic or network structure.
- (2) Preparing pairwise comparison matrices.
- (3) Collecting field data.
- (4) Using the Super Decisions software (<http://www.superdecisions.com/>) and obtaining the priority weight for each alternative.

(1) *Building a hierarchic or network structure*

Based on the prior exposure to five main pressures in the global context, our participants defined the GOAL and SURVEY ITEMS. As shown in Figure 4(a), five main pressures discussed before are considered as survey items.

(2) *Preparing pairwise comparison matrices*

To develop priority weights for items, our participants are asked to fill out a pair-wise comparison form, based on a pair-wise comparison of two items at a time (see Appendix, Table 1).

(3) *Collecting field data*

The general approach of the AHP data collection procedure described by Madu *et al.* (1991) and Delbecq *et al.* (1975) is adopted and followed here. As a result, a structured group (executive MBA students) meets to review problems, discuss factors/items at hand (a leader is in charge of questions, interpretations or explanations) and vote on factors/items based on a pairwise comparison table (see Appendix 1). Our participants were also instructed to use the following nine-point scale system to assign their judgments:

When comparing item  $i$  and item  $j$ , select a numerical value  $A_{ij}$  from the following set:

- 1: Item  $i$  and item  $j$  are of equal importance.
  - 3: Item  $i$  is weakly more important than item  $j$ .
  - 5: Item  $i$  is strongly more important than item  $j$ .
  - 7: Item  $i$  is very strongly more important than item  $j$ .
  - 9: Item  $i$  is absolutely more important than item  $j$ .
- 2, 4, 6, 8: Intermediate values between the two adjacent judgments.

Further,  $A_{ii} = 1$ . If  $A_{ij} = y$ , then  $A_{ji} = 1/y$ .

(4) *Using the Super Decisions software and obtaining the priority weight for each alternative*

Our participants' judgments were analysed using the Super Decisions software package. The results are presented in Figure 4(b). Since all inconsistency values are less than 0.1, the AHP results are considered to be consistent. The result shows that of the five identified survey items, outsourcing (with a priority index of 0.459) is seen as the most significant factor in today's business environment in Taiwan. The results further show that adopting advanced technology is important. This item gets a priority index of 0.23. Developing communities, however, is seen by our participants in Taiwan as of least importance.

At the conclusion of this exercise, our participants are properly prepared to understand the decision complexity in a global supply chain setting. It reflects the current state of knowledge and the complexity of phenomena in question. It helps raise our participants' awareness of complex business issues and the need for acting on the basis of decision science theories.

Part of this exercise is also to understand the intended strategic direction assumed by the executives of the multinational enterprise under consideration. Presently, there are many big corporations in the Asia-Pacific region that produce digital consumer products such as LCD TVs, network-connected devices, and home appliances. Technological knowledge and skills in this area are quite matured and the market is relatively stable. It is therefore necessary for the firm in question to define the strategic aspects clearly from the start in order to design, organise, and prepare for responsible change through SCQ initiatives. After a lengthy interview with the corporate executives responsible for global operations with respect to this particular concern, an affinity diagram is constructed (see Figure 5). Two essential steps are adopted here when constructing such a diagram:

- (1) Identifying ideas that can contribute to the resolution of the issues at hand.
- (2) Sorting the ideas into a number of related groups.

As can be seen in Figure 5, four major themes are identified and reported: design for six sigma (DFSS), international standards, supply chain management (SCM), and global leadership and human resource management. This finding is consistent with that of Ogulin (2003) and Kuei *et al.* (2008). These four themes, in the context of global SCQM, frame the SCQ problem space. Actual SCQ solutions are dependent on the decision making models adopted in the decision component of our proposed SCQM framework (see Figure 3).

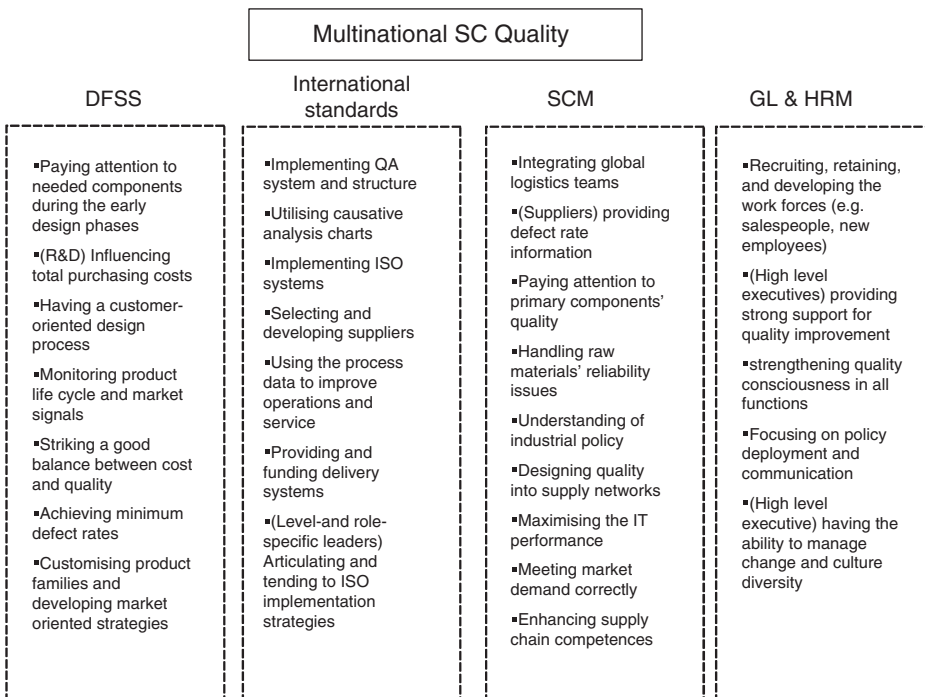


Figure 5. Affinity diagram.



#### 4.2 Strategic choice with the AHP

In the discussion above, we noted the importance of finding what the company's intentions are. This could be done through the use of an affinity diagram. It is equally important that the strategic intents are prioritised. The next phase of this exercise as a result is to use the AHP model in prioritising such intents. This structured approach will ensure the consistency of the priorities and solutions that are found. Due to time and resource constraints, we did not go back to the firm in question for the second round of exercise. Instead, we asked our EMBA students to fill out a pair-wise comparison form derived from the AHP structure (see Figure 6) with respect to the new found strategic options. At this stage, we also note that the goal in the AHP network diagram is 'multinational SCQ development strategies' (see Figure 6). The results are presented in Figure 6. Clearly, from this example, we see that the most important factor is global leadership and human resource management, followed by SCM. This result is consistent with the notion suggested earlier, that is, the purpose of SCQM is to create a sense of SCQ community in the global economy. This new development also supports the thesis proposed by Lambert *et al.* (1998). They suggest that firms with supply chains need to pay attention to developing both managerial and behavioural capacities. These simulated weights need to be taken into consideration in determining the details of global SCQM system development strategies.

#### 4.3 Tactical choice with the AHP

Modern multinational enterprises are increasingly faced with the problems of supplier developments, technology management, and sustainable operations. Rather than responding to issues and problems described by the channel partners, we suggest that today's enterprises with global supply networks should find better ways to proactively force issues out. Along the decision cycle of our proposed global SCQM framework, this implies interdependence between decision making models where the output of our strategic choice could become input in the next round of decision making. This new round of exercise, still based on the AHP model, has been called the 'tactical choice' – a practice that can 'provide an understanding of the formal mechanisms by which organisational units can be made to

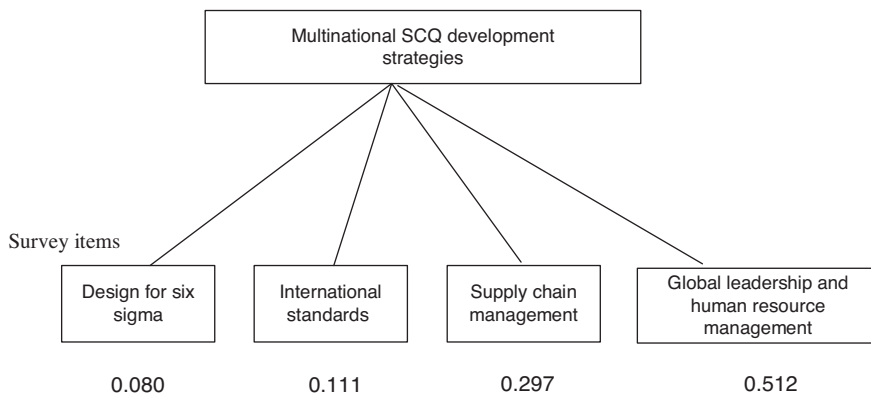


Figure 6. AHP hierarchy – strategic choice.

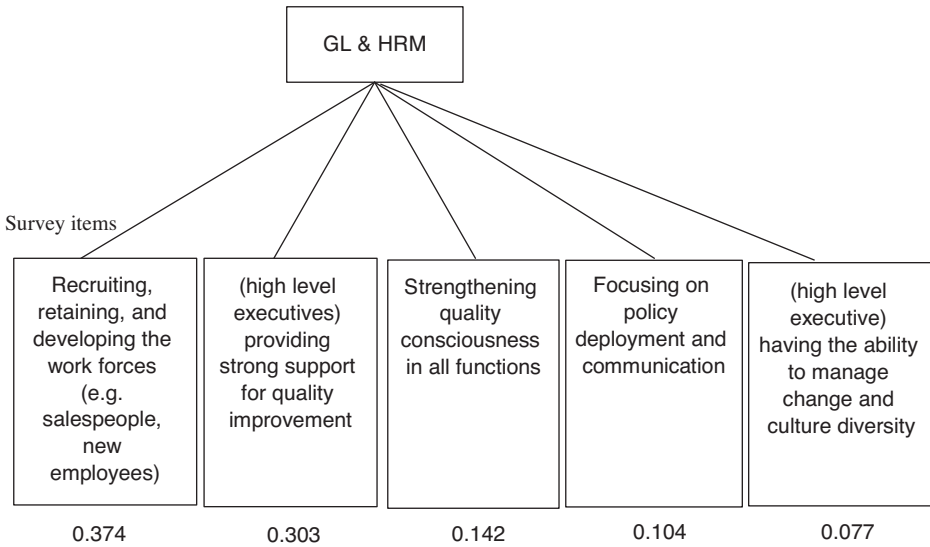


Figure 7. AHP hierarchy – tactical choice.

coordinate their activities in a decentralised manner (Gigch 1978, p. 386)’. Global supply network is a complex, living system. To design and realise quality conscious products in a global network setting, there must be shifts from the traditional internally focused operations and process paradigm. In this paper, the shift toward ‘Global SCQ’ has introduced new dimensions in product and service realisation in a decentralised global business environment. An exercise about planning supply chain activities to meet market demands and/or SCQ development strategies thus is in great need. With this in mind, we asked our participants again to assign their preferences on each pair of tactical alternatives (see Figure 7) under consideration. Before the assignment, the goal and tactical options are discussed. The results are also shown in Figure 7. It is observed that the most important initiative is ‘recruiting, retaining, and developing the work forces’ with a relative priority weight of 0.374. The results further show that ‘high level executives’ strong support for quality improvement’ is also important. This item gets a priority index of 0.303. The firm in question, based on the evaluation of our participants, as a result should direct more attention and resources in implementing initiatives with high priority weights. In other words, the management team should consider developing a tactical mix that comprises a unique blending of the items derived from the AHP exercise.

As modern multinational firms adopt the decision-making approach presented in this section, they understand environmental scanning and both strategic and tactical choices are of great importance in a global business environment. Through efforts co-ordinated by modern multinational firms, their supporting supply networks in the global market place have better odds of attaining overall supply chain quality.

**5. Managerial implications**

The global SCQM system means different things to different enterprises. It is therefore our intent to propose a broad outline, with a special focus on SCQ, to promote the interaction

among subsystems along a global supply chain. With this aim in mind, we have developed a framework through incorporating the following three aspects: design, system, and decision. When explaining such a complex meta-system, we first focus on the details of design components, system components, and decision components. We then demonstrate with a case study how global SCQ are achieved through the adoption of the decision making approach.

A number of observations along the cycle of decision making are elaborated here.

First, the decision-making approach presented in this study (see Figure 3(b)) offers a step-by-step approach, along three hierarchical levels (environmental scanning, strategic problems and choice, and tactical problems and choice), towards a complicated decision making situation. Good strategic/tactical decision making is fundamental for achieving global SCQM under uncertainty. To this effect, it is most important to choose the best set of decision making tools for both policy deployment and quality management along the supply chain.

Second, this paper also explores global SCQM through a case study in Taiwan. This part of our paper aims to:

- (1) Support the components of our conceptual model (see Figure 3(b)).
- (2) Identify the most important issues (and the least important issue) from stakeholders' perspective.
- (3) Explore SCQ strategies under uncertainty.

Our data show that the two most important challenges turn out to be outsourcing and adopting advanced technology. As suggested by Handley and Benton (2009), focal firms and their channel partners as a result need to undertake extensive strategic evaluation on sourcing quality. It is not possible to have six sigma performance with three six sigma sourcing quality. Further, multinational enterprise in question also needs to adopt advanced technologies as the backbone of company operations before deploying other enterprise systems (Su and Yang 2010). Using this empirical finding as a source of input (see Figure 4(b)), four strategic directions were identified by senior executives from a Taiwan-based computer and electronic home appliance manufacturer. The exercise described in the present study (see Figure 5) helps address the concern on 'where to' part in the strategic planning and set up the stage for strategic choice (see Figure 6). The least important issue turns out to be community development (see Figure 4(b)). This finding is consistent with empirical studies conducted in Hong Kong by Welford *et al.* (2007). Sustainability, however, is the current trend across the world and it should last as long as it can since earth's resources are limited (Kuei and Madu 2009). To respond to this challenge, over the next few years, a wide array of visions and executable actions should be produced based on the principles of the triple bottom line (Elkington 1997, 1994). It would be interesting to verify our current findings in a different case study in the Asia-Pacific region. We therefore suggest that future research may investigate further according to the architecture of our hybrid model (see Figure 3(b)) and new paradigms of triple bottom line.

Third, at the environmental scanning level, the discussions regarding new challenges and pressures expanded the worldviews and understanding of our participants about the problem at hand. Enterprises in the Asia-Pacific region, not surprisingly, are under increased pressure to outsource more and also to try to do it quickly. As a result, sourcing quality may play a far greater role in global SCQ decisions in the long run. Modern enterprises need to therefore focus on the following sourcing quality constructs: supplier

capability, supplier quality, supplier–buyer relationship, inventory accuracy, transportation quality, and delivery reliability (Madu and Kuei 2004). Based on our affinity diagram analysis, we further note that there are many ways to fuel enterprise's growth and long term competence developments. Four areas are identified according to our interviews with senior executives. They are:

- Design for six sigma (DFSS).
- International standards.
- Supply chain management.
- Global leadership and human resource management.

These four strategic areas might have the potential of creating a performance advantage in terms of SCQ in the long run.

Fourth, at the strategic choice level, as mentioned earlier, it is necessary to define the functional aspects of the global SCQM system. One question that persists in this regard is 'What should our enterprise do, given objective and subjective system constraints?' Based on our AHP analysis, we have learned that our multinational enterprise needs to emphasise global leadership and human resource management as a foremost area of future SCQ developments. This begins with the understanding of current operating environment and trends and strategic choices available. As suggested earlier, the most current trends are globalisation, digital frontier, and sustainable economy. To improve the odds of success, modern enterprises may no longer ignore the demands of leadership training and personnel developments. There is, therefore, a need to focus on the following four elements of leadership and talent developments: systems thinking, management for change, ethics, and decision and design science. This finding is in perfect agreement with that of Madu and Kuei (2004).

Fifth, at the tactical choice level, it appears that the enterprise must show concern for its workforce along the global supply chain and its immediate environment. Organisational commitment to employees is the must-have attribute in global supply networks. Employees of the entire supply network must derive pride and joy from work and tie their future with the organisation. Kiviat (2009, p. 46) also notes that 'jobs are the new assets' in today's global economy. This is also replicated in the results shown on the bottom of Figure 7. That is, developing and retaining the work force is of paramount importance in the current global market. Quality improvement is also seen as another important message. Top management must be committed to the goal of quality improvement. Management actions should be taken to ensure that overall SCQ improvement goals are achieved. This conclusion is also consistent with that of Gharajedaghi (2006) and Kannan and Tan (2005). Thus, there is a need for modern organisations to focus on the following four elements:

- Behaviour realisation.
- Function realisation.
- Structural realisation.
- SCQ competence developments.

Like any complex system developments, implementing global SCQM system is an ongoing challenge for today's multinational enterprises.

Sixth, the AHP is used in this study as one of our major decision-support tools to evaluate different survey items and provide a basis for social actions in a complex business environment. In future studies, we shall adopt the analytic network process (ANP)

approach to allow for the possible interdependencies among and between levels of elements along a hierarchic structure.

Finally, to survive in an increasingly competitive international marketplace, we must consider new dimensions for management of quality. These new dimensions are based on a new framework known as global SCQM system. This system is built around three issues: design components, system aspects, and a hierarchy of problem solving methods. In the framework, communication and coordination are considered as integral parts of our proposed global SCQM system (see Figure 3).

The discussions here are intended to promote thoughtful discourse with respect to global SCQM, and offer guidelines to modern enterprises concerning the critical factors that may affect the successful implementation of such a system.

## 6. Conclusions

Multinational corporations today cannot operate effectively without a global supply network. There are many components that must be linked or combined to form a physical domain of supply networks as well as a conceptual framework of SCQM. The physical domain generally outlines the objective reality. The conceptual framework provides a basis to shape and transform systems of concern from the current state to a preferred one. In the previous sections, critical variables are arranged according to three distinct groups in our conceptual framework: a hierarchy of design variables, a hierarchy of system variables, and a hierarchy of problem solving methods. Each group is composed of a number of items. There are many ways to explain such a framework. For the purpose of this study we first organise our presentation from a more theoretical point of view. As a result of this development, details of three distinct groups (i.e. design, system, decision) are discussed. This theoretical framework enables global enterprises to form a vision, frame a design and problem space with respect to global SCQ, and lay emphasis on the benefits of global supply chain networks. We also illustrate one aspect of our proposed framework, namely, the cycle of decision making, from empirical perspectives. It is our belief that globalisation demands that practising managers and supply chain executives learn how to shape and re-evaluate SCQ development strategies along the cycle of decision making. For this purpose we engage in three AHP-based applications and conduct interviews. This practice, if adopted appropriately, may enable practising managers to communicate with each other, perform proper analytical analyses, and make quality decisions in a timely and effective fashion. The decision-making approach enables enterprise value chain partners to focus on initiating and delivering global SCQ required to satisfy the market demands.

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## Appendix

Table 1. Pairwise comparison table – goal.

With respect to business environment, please make your judgements about the relative preference/importance of item *i* and item *j*.

	Pressure to outsource	Pressure to protect the environment	Pressure to reduce wastes	Pressure to reduce wastes	Pressure to adopt advanced technology
Pressure to outsource	1				
Pressure to protect the environment	X	1			
Pressure to reduce wastes	X	X	1		
Pressure to reduce wastes	X	X	X	1	
Pressure to adopt advanced technology	X	X	X	X	1

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