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Review

The future of operations management: An outlook and analysis

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ABSTRACT

Managing operations in both manufacturing and service organizations have evolved tremendously over the years with the change in market requirements. The market has become global, thereby compelling enterprise operations to keep up. The application of information technology/information systems (IT/IS) and outsourcing in managing operations have significantly altered the landscape of operations management (OM) strategies, techniques, and technologies. Consciousness towards environmental and safety also urges companies to examine their OM approach and manufacturing from various perspectives. Recently, energy cost and protection against terrorism have changed the portfolio of enterprise operations and therefore the approach to OM. Now, it is time to revisit the OM principles, curriculum, and training at the institution of higher learning and industries. Moreover, manufacturing has become more of a service activity, indicating significant service OM, including project management. The profile of service industries has also changed in view of the emergence of globalization, outsourcing, and IT, coupled with the rapid economic growth of emerging economies such as Brazil, Russia, India, and China (BRIC). In fact, services account for approximately 80% of the US gross domestic product (GDP); this is also a growing figure of the GDPs of other countries over the world. Again, service OM needs to be revisited in the context of the abovementioned paradigm shifts. In considering the significance of the above-mentioned changes in the market and society as a whole, an attempt is made to study the evolution of OM and subsequently to develop a framework for new OM strategies and tactics that will support the competitiveness of organizations within the next 10–20 years.

Contents

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1. Introduction

Advancements in information technology (IT), globalization of markets, decentralized operations, and increased consciousness towards environmental concerns have compelled industries to rethink their productivity and quality strategies and techniques, including the overall operations management (OM) approach. This phenomenon calls for the revision of the educational curriculum and training accordingly. In the early years, Japanese competitiveness in terms of both productivity and quality has prompted companies in other countries to think about their own productivity and quality problems seriously. Moreover, OM has evolved from mass production to mass customization. During this paradigm shift, companies have implemented a number of new operations strategies, techniques, and technologies to compete in the global market. These strategies include just-in-time (JIT) strategy, total quality management (TQM), flexible manufacturing systems (FMS), computer-integrated manufacturing (CIM), agile manufacturing (AM), lean production (LP), business process reengineering (BPR), quick response manufacturing (QRM), and supply chain management (SCM).

In the past 15 years, the Internet has transformed the way companies operate and function in terms of acquiring resources and meeting customer expectations (Gunasekaran et al., 1995). The question now is whether traditional OM principles and techniques, including strategic planning, scheduling, inventory and quality control, and human resource management, are applicable to new enterprise environments, such as SCM, enterprise resource planning (ERP), the Internet, radio frequency identification (RFID), customer relationship management (CRM), outsourcing and third-party logistics (3PL), and knowledge management.

The objectives of this research are as follows: (i) to review and analyze the evolution of OM; (ii) to review the development of enterprise environments and markets over the years; (iii) to understand the evolution of society; (iv) to analyze market transformation based on societal development; (v) to study the evolution of OM; (vi) to understand productivity and competitive strategies; (vii) to identify the gap between socioeconomic and OM; (viii) to forecast new OM paradigms, techniques, and tools; and (ix) to provide a summary of findings and conclusions for application and limitations.

Different types of research methodologies allow practitioners to derive new insights into future operations paradigms. For example, Craighead and Meredith (2008) review the evolution of OM along (i) the rationalistic versus interpretive orientation of the researcher, and (ii) whether the researcher desires observational or artificial data to embody these two patterns of interest. If the research becomes more interpretive and observations based, the findings will have greater relevance for managers. However, the case study without adequate theoretical and conceptual background may not lead to significant insights into the subject. Taylor and Taylor (2008) highlight the need for novel approaches to OM research in the automotive sector. This is particularly important when differences between production systems seem to disappear. A number of recent empirical evidence suggests that lean management extremely depends on consultants, which is against depth of knowledge and employee involvement. This appears to be true especially when lean management is conducted from the perspective of improving operational and strategic performance, which is critical for any organization.

Bayraktar et al. (2007) analyze the evolution of OM and potential developments in the relevant areas of OM. Virtual enterprises emerge when demanded by a dynamic marketplace and disappear in the absence of a market. Appropriate OM models should be developed to address the following: (a) synthesis and architecture for converting information into knowledge; (b) unified communication methods and protocols for the exchange of information; and (c) adaptable and reconfigurable manufacturing processes and systems. Virtual enterprises and organizational perspectives must be present to continue playing a major role in organizational competitiveness in the 21st-century global markets. This indicates that OM principles and strategies should be modified to determine make-or-buy decisions on the following:

- Partnership formation.
- Organizational architecture for manageability and at the same time for satisfying the needs of the changing market.
- Information systems and their reconfigurability based on the dynamics of virtual enterprises or organizations.
- Management structure and models that succeed in virtual enterprises or organizations.

In this paper, an attempt is made to determine the characteristics of future OM with the objective of assisting emerging organizations with their competitiveness in the next 10–20 years. Basic methodology used is to review extant literature on the evolution of OM (both manufacturing and services) as well as the authors' own experience in conducting research over the past 25 years. Societal and market evolution has been considered in developing a framework for future OM principles, strategies, and tactics. Fig. 1 summarizes the evolution of OM based on societal and market evolutions.

The rest of the paper is organized as follows. Section 2 discusses societal evolution to highlight the changes in culture and the expectation of the society in terms of better standards of living and ways to leverage opportunities that the global village can offer. Section 3 explains that based on the evolution of society, the expectations of people have changed over time, thus influencing the nature of markets for various products and services. This section also identifies future market characteristics. Section 4 presents the evolution of manufacturing, and Section 5 analyzes the gap between current and future market needs as

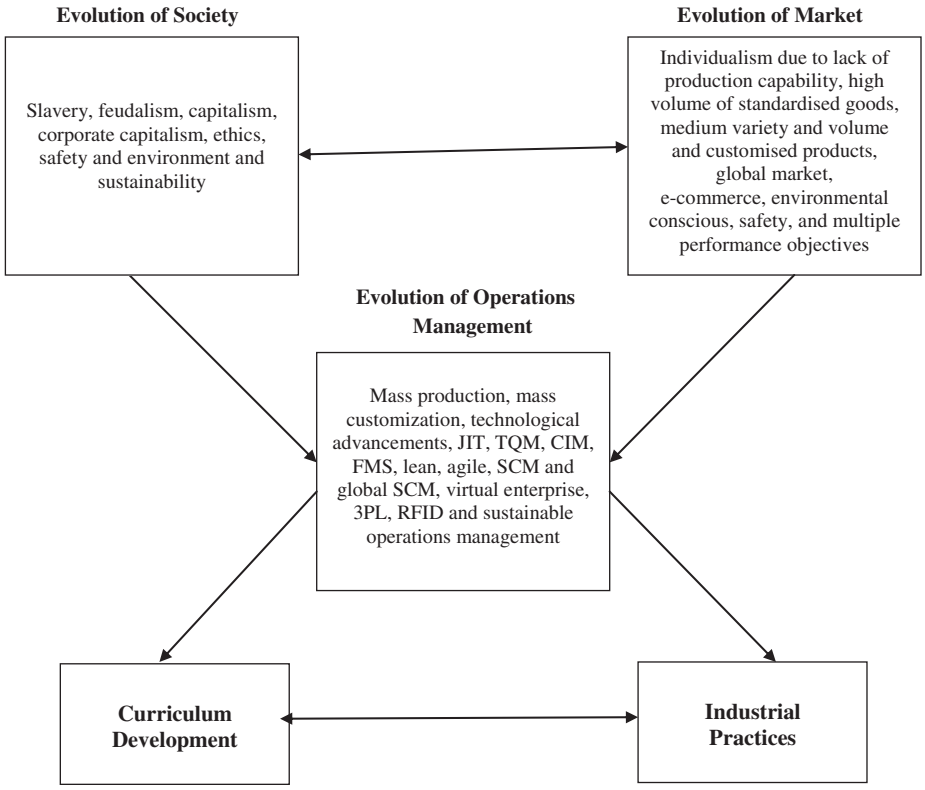

Fig. 1. Evolution of OM paradigms.

well as the profile of OM (principles and techniques) with the aim of determining the profile of new OM. Based on these analyses, a framework for the new OM function is proposed in Section 6. Finally, Section 7 concludes the paper with suggestions for further research.

2. Societal evolution

Market evolution is closely followed by societal evolution and vice versa. The evolution of both society and market is closely related. Sherman (2005) traces the evolution of human institutions from prehistoric communal societies through slavery, feudalism, and capitalism to corporate capitalism (McClough, 2007). He discusses a shift from one economic system to another by studying the role of technological innovation in the ability of an individual to produce surplus, thereby creating wealth. Back then, there was a need to protect wealth through the establishment of political institutions that evolved to represent the interests of those who controlled the surplus. Change in the political landscape in the US has triggered significant changes in its role as well as the growing importance of emerging economies in influencing the economic landscape of the entire world. This indicates the implications of cultural integration and subsequently business integration, which leads to serving humanity with a better standard of living while respecting the perspective of sustainable operations management and business development by protecting the environment, safety, and ethical values. Sherman (2005) highlights the implications of economic stagnation that arises from a lack of technological innovation spurred by political and social institutions that distort, if not eliminate, incentives for innovation. Only in crisis is implementing institutional change that challenges the status quo possible.

An example is the economic crisis in 2008 that resulted in a number of changes in both public and private sector organizations. This crisis triggered a change in policies of institutions, such as banks, insurance, and real estate. Organizations experienced numerous changes during this period of recession, such as equity valuation, elimination of greed, controlled employment policies, ethics, global economic integration, and so on. Different policies related to minimal income support and wage helped to maintain demand during periods of recession, allowing capitalist ventures to survive the economic recessions. Global capitalism commenced with the collapse of the Soviet Union and the commitment of China to introduce capitalism, which has become the economic system throughout the world. Sherman (2005) emphasizes the role of technological innovation in corporate globalization. Specifically, he identifies innovation in communication and transportation, which serve to promote capitalist ideology throughout the world. Economic democracy follows political democracy, but not necessarily in the way it is viewed in the case of China. China has become an economic powerhouse, and it currently enjoys greater influence on world trade and economic policies. This implies that emerging economies continue to influence the policies of other countries, including those of developed economies. Smaller and developed economies will face certain challenges stemming from the competitiveness of emerging economies not only in production but also in the development of innovative products and services.

Watanabe et al. (2006) argue that Japan's rapid economic growth after World War II can be attributed to its remarkable technological improvement through the tremendous efforts of the industry to invest in research and development (R&D), resulting in technological innovation that contributes to the improvement in productivity. Japan constructed a suitable cycle between technology and economic development (Watanabe, 1995). It has experienced economic stagnation over the last decade because of its propensity to abide by the traditional business model. This stagnation is based on growth oriented during a high economic growth period from an industrial society to an information

society and a low economic growth year under a mature economy (Watanabe and Nagamatsu, 2003). The economic recession from 2007 onwards has urged companies around the world to identify cost-cutting measures and to exert innovative efforts for sustainable operations management and business development with due consideration to economic and global challenges (Watanabe and Ane, 2003). Now, the issue of OM evolution should be developed in tandem with major the emerging economies and their manufacturing and service competitiveness.

According to Schwaninger (2004), the world is in the midst of a crisis, fraught with conflicts between the rich and the poor, ecological catastrophes, economic instability, drugs, corruption and crime, terrorism, social degradation, and epidemic. He discusses the conscious evolution of organizations and society based on four concepts: complexity, autonomy, recursion, and control and communication. With conscious evolution, the path of social systems is not left to chance. Socioeconomic evolution is not a spontaneous occurrence; rather, it is influenced by government policies, economic regulations, political stability, poverty, gap between rich and poor, globalization, and the growing importance of sustainable operations management and business development and corporate social responsibility. This can be an example of evolution designed by the abovementioned factors (Schwaninger, 2004). Furthermore, Schwaninger (2004) states that cybernetics is the science of communication and control. The evolutionary potential inherent in the models and conceptual tools of managerial cybernetics is immense. This potential can be utilized in building bridges towards a sustainable future for humanity. However, cybernetics is beneficial in a controlled environment; for societal evolution, a more holistic approach is more appropriate (Mingers and White, 2009).

Nevertheless, cybernetics produces a tremendous impact on societal evolution. For example, recent developments in information technology/information systems (IT/IS) or communication technologies have created a profound impact on the development of the global society evolution. However, the imbalance of wealth distribution has a holistic approach towards managing problems. The Internet provides tremendous opportunities for advancing social, economic, and educational development. However, the digital divide that separates individuals with different backgrounds prevents the socially and economically disadvantaged from maximizing digital opportunities (OECD, 2001). The digital divide is a widely discussed subject that requires a social and economic approach to overcome the imbalance in the society and to design a more balanced society through technological evolution and innovation, and macroeconomic government and industrial policies. Accordingly, business and marketing models should be designed as well as OM models that support the well-being of humanity.

Belardinelli (2002) highlights the importance of family in a business culture. He believes that the trust exhibited by the family of today has a critical role to play in society; it is in the family where responsibility and entrepreneurial ventures are encouraged in a liberal democratic culture. There is a gap between the business world and family life. Husbands and wives are becoming more and more involved in business or in the workforce, and this situation gives them little time to instill ethics in their children's mind and behavior. Family and business influence each other's well-being and success. Family members have limited time to integrate ethics and trust among each other. Thus, business schools have taken responsibility for this task. However, this has limited impact on the final outcome. Therefore, proper political processes and policies should be in place.

With time, the society evolves with changes in technology, business, culture, and so on, indicating that the needs and expectations of the society change as well. Now is the time to look ahead and to design and develop economic systems accordingly, including enterprise design and operations. Recognizing the changes in the needs and expectations of the society requires revisiting current enterprise operations and paradigms. Thus, the objective is to develop a new OM system that will address the needs of the society for the next 10–15 years or so.

3. Market evolution

Previously, the market was based on individual requirements due to the lack of adequate production capability. Therefore, when the market for consumer products increased, companies began to focus on producing a high volume of standardized products. Once the demands for customers' basic needs were met and along with prosperity and economic growth, customers began to expect customized products. To meet this demand, companies began developing production systems capable of producing medium variety and volume of goods. Currently, the market has transformed from local to global, and demand has shifted from standardized products to customized products. The 21st-century market is characterized by global, knowledge-based, IT-driven, customized, and cost-competitive products and services. E-commerce will continue to change the profile of markets, and the future of markets will be more virtual considering the energy price and recession. Economic competitiveness will be leveraged, spurring various trade liberalization policies and agreements in different countries and regions and necessitating the need for change in the OM curriculum and industry practices.

Globalization, change in customer expectations, and advancements in IT have changed the competitive priorities of firms (Lee and Whang, 2000). To remain competitive in the global market, organizations are compelled to reengineer operational capabilities, such as quality, flexibility, speed, services, and costs (Zhao and Lee, 2009). Business competition continues to shift from individual enterprise versus individual enterprise to supply chain versus supply chain. Companies not only integrate business processes into the company but also into the so-called extended enterprises, namely partnering firms or that of suppliers.

Soberman and Gatignon (2005) present a framework for understanding the interactions between market evolution and competitive dynamics. The framework consists of four dimensions: (1) effect of competitive dynamics of market evolution; (2) market evolution; (3) effect of market evolution on competitive dynamics; and (4) competitive dynamics. The effect of competitive dynamics on market evolution depends on performance objectives, strategic investment in capacity and R&D, timing of new product launches, and marketing mix decisions. The impact of market evolution on competitive dynamics is based on the strategic attractiveness of the market, market entry and exit, and evolving customer response (Soberman and Gatignon, 2005). The relationship between market evolution and competitive dynamics is twofold and influences each other. For example, Apple Inc. constantly launches new products and in a way creates competitiveness, leading to market evolution for other companies.

Duplaga and Pinto (2002) discuss adopting production processes to respond to evolutionary changes in market conditions with the help of a case study. Companies must provide products that satisfy the changing consumer preferences in the global marketplace while maintaining corporate social responsibility, stringent costs, and quality standards. Berthon et al. (2000) develop a conceptualization of market evolution based on an information-processing perspective and an evolutionary view of market development. The conceptualization deals with the

meta-level of analysis and examines the dynamic power relationships between producers and customers. Combining producer market power and customer market power suggests four types of situations: (1) benign coexistence; (2) industrial revolution toward the production economy; (3) customer supremacy in the service economy; and (4) strong interaction through the emerging information paradigm (Buzzell, 1999). Buzzell (1999) discusses three important topics in market evolution: sociocognitive dynamics in a product market (knowledge structures shared by producers and customers), marketing in technology-intensive markets, and modular architecture in the new marketing process. In the 21st century, the power of industrial houses in terms of unveiling innovative products certainly influences market evolution and therefore overall competitive priorities. This is for the benefit of 21st-century, technology-savvy customers.

As earlier discussed, societal evolution demands changes in marketing and operations functions. In the past, both academic researchers and practitioners appeared to have ignored this important dimension while developing strategies and tactics in marketing and operations functional areas. If the operations function truly intends to contribute to the well-being of the society through well-articulated marketing strategies consistent with socioeconomic demand, then there is a need to integrate societal issues while looking ahead for future marketing and OM functions. These issues include curriculum issues for developing suitable skills and providing training for students in OM and other functional areas. With these objectives in mind, an attempt has been made in this study to review the societal and marketing evolution. Based on this, a framework is designed for future or emerging operations paradigms. The detailed evolution of OM is presented hereunder based on the analysis of societal and marketing evolutions and on information available in the existing literature.

4. Evolution of OM

OM has shifted from mass production to mass customization. At the onset of its evolution, skilled artists produced products based on individual customer requirements. However, this required a greater amount of time, flexibility, and less responsiveness. In the wake of World War II, a massive demand for consumer products emerged. Therefore, companies were pushed to produce standardized products in large volumes. To cope with the demand, companies developed a transfer line and a mass production system. After the basic product requirements were met, customers began expecting high-quality products for a lesser price. Thus, companies developed operations strategies such as TQM and JIT production systems.

Once the basic needs of customers in terms of quality and price were satisfied, they began to expect their individual needs to be satisfied through mass customization (e.g., flexibility and responsiveness). In response, companies started to implement computer integrated manufacturing (CIM), flexible manufacturing system (FMS), and agile manufacturing strategies and technologies. Eventually, the market became global, necessitating companies to opt for global operations based on international operations, joint ventures, and outsourcing backed by strategic alliances based on core competencies. Furthermore, the market called for leveraging people and IT. Companies were compelled to compete based on all competitive performance objectives, such as price, quality, flexibility, dependability, and responsiveness. Thus, companies developed operations strategies and techniques such as BPR, lean, AM, and SCM. Since the emergence of electronic commerce (e-commerce) and various trade agreements, such as the North American Free Trade Agreement, European Commission, and Association of South East Asian Nations, companies were left with no choice but to be flexible and responsive to the changing market requirements.

Subsequently, SCM became popular among companies that consider the integrated business process perspective, which is essential for the physically distributed enterprise environment along with the Internet and ERP. Now, companies focus on developing an RFID-based supply chain to deliver total business visibility and to serve global customers better. Table 1 presents the brief evolution of OM.

5. Literature review on the evolution of OM

The evolution of OM is classified based on the different phases of supply chain management: (1) productivity and competitive strategies; (2) physical inflow of materials; (3) production planning and control; and (4) physical outflow of materials. Meredith (2001) and Zhao and Lee (2009) highlight a number of major trends in OM, which are as follows: (i) importance of resource-based theory and transaction cost theory; (ii) management issues in the supply chain with regard to trust, commitment, and configuration; (iii) choice of operations from institutional, contingency, and configuration theory; and (iv) relationship between operations and supply chain strategies using contingency theory and configuration theory. These are the latest trends in OM. Baldwin et al. (2005) provide an overview of the modeling of manufacturing evolution for sustainable industrial development.

5.1. Productivity and competitive strategies

Productivity and competitive strategies have transformed based on the change in marketing dynamism and the evolving organizational structure and operational performance. Papke-Shields et al. (2006) study the evolution of the strategic planning process of organizations in terms of "rationality" and "adaptability" of planning. They reveal that irrespective of the firm's environment, a greater degree of "rational adaptivity" is correlated with better planning outcomes and business performance. First, competitive strategies should be aligned with corporate strategies, and subsequently competitive strategies should be aligned with productivity strategies. To formulate a corporate strategy, companies usually examine both internal and external factors. In the 21st-century enterprise environment, higher priority is accorded factors that are

Table 1
Evolution of operations management.

Period	Objectives	Strategies/technologies
Beginning	Individual customer requirements	Craftsman production, artesian production
Post-World War II	Immense demand for consumer products	TQM, JIT, transfer line production systems
1975–1985	Medium volume and medium variety	QRM, CIM, FMS, and BPR
1985–1995	Cost reduction, high variety, and low volume	Lean, agile, and physically distributed enterprise environments
1995–2010	Higher variety and very low volume	Outsourcing, global manufacturing and market, agile, Internet-enabled SCM, 3PL
2010–	Global individualized products and services	Global SCM, virtual enterprise, RFID-enabled SCM, sustainability.

external to the organization. For example, supply chain operations (with a considerable number of external partnering firms or suppliers that are geographically distance from each other) are physically distributed through outsourcing and IT applications.

According to Skinner (2007) in his thought-provoking article, "The US production managers [are] attempting to fight big battles with small weapons, and the small weapons are being provided by academics." This is what the present study intends to examine in view of the immense level of changes that have occurred in the society, market, and enterprise environment. Companies employ less of the traditional approach for manufacturing products and producing services. For example, they do not intend to focus extremely on internal factors because organizational competitiveness and productivity depend mostly on external factors; however, this should be conducted at the operational level decision-making. As the market is no longer domestic because of various trade liberation agreements and policies, strategic formulation and implementation should be consistent with the global view, such as the international market, outsourcing, and IT. The OM function in the 21st-century enterprise environment has become a service function. This indicates that for manufacturing products and services, companies or firms should trade resources, such as commodities. This also indicates that knowledge and strategic management are critical for procuring required resources to manufacture and deliver high-quality goods all over the globe as soon as possible and at competitive prices.

US companies cannot simply live on the past glory of being among the top producing countries in the world. Majority of the classes keep teaching the traditional OM functions and their effectiveness in productivity and competitive strategies. As OM has evolved following the emergence of computer technology, revisiting an OM curriculum is a worthwhile endeavor. If the US intends to continue being the world economic superpower, it must focus on manufacturing that is out of the box or think innovatively and strategically. Therefore, all these will become the key factors of competitiveness of US companies. Judging by competition from the EU and other emerging economies such as Brazil, Russia, India, and China (BRIC), now is the right time for US businesses to rethink their corporate, competitive, and productivity strategies completely (Table 2). Without a doubt, the rapid growth of BRIC has changed the competitive landscape in both manufacturing and service industries. Therefore, testing empirically the majority of theories largely derived from research in Western countries is a challenge for academics. Culture and environmental issues play a major role in determining future directions, operations, productivity, and, in turn, competitive strategy.

Balakrishnan et al. (2007) discuss factors that influenced the developments in industry and manufacturing in Canada from the 17th–20th century. The manufacturing industry was not significant in Canada until the early 19th century because it drew on abundant natural resources that led to the development of primary industries in the 17th and 18th centuries. According to the paper, there are multiplicities in factors that have shaped today's Canadian manufacturing. These multiplicities include war, politics, natural resources, trade agreements between countries, transportation, electricity, foreign direct investment, and government support for industry. Perhaps, these factors may have significant influence on emerging economies as well.

5.2. Physical inflow of materials

The OM trend in this phase of the supply chain has evolved throughout the years. The physical inflow of materials seems to dominate the production part of the chain as majority of components and parts are outsourced and/or purchased. In developing new OM principles and techniques, one cannot simply ignore geographical differences in terms of demographics and natural resources. For example, Latin American countries enjoy abundant natural resources, but their human capital has yet to be maximized; majority of the returns can be derived from factors other than primary goods (Moreira, 2009). While productivity and competitive strategies are critical, it is also important to leverage the human capital rather than cause an imbalance in natural and environmental resources and leave a greater carbon footprint.

Supply management has become critical because the sourcing of products is performed globally. This places a tremendous pressure on selecting the right partner firms and suppliers to ensure that the right parts and components are made available for the completion of value-added operations. Purchasing should be viewed more strategically to achieve the long-term objectives of supply management. While formulating decisions on supplies, a make-or-buy and onshore-and-offshore purchase of materials should be considered. Moreover, intangibles and hidden costs and benefits, including strategic implications, should be considered while formulating decisions on sourcing. Various risks involved both in short- and long-term supply relationship should also be considered. The reason is that sourcing can be global and can pose additional challenges such as security, customs, political stability, currency fluctuation, and environmental standards. The current focus of supply management requires a different mindset;

Table 2
Comparison of traditional strategies and future strategies in organizations.

Areas	Traditional strategies	Future strategies
Corporate	External factors such as competitors, market, environment, general economic conditions such as inflation, employment rate, and cost of living; internal factors such as infrastructure and company culture; limited global perspective and operations; excessive emphasis on technology, less on strategic alliances and core competencies; lack of trust and respect for collaboration; lack of respect for safety and environmental concerns; lack of social well-being and equity; extreme protectionism; poor business law; and cultural barriers	External factors such as global market, politics, terrorism, poverty, civil war, energy, environmental, global economy, employment rate, international cost of living, salaries; internal factors such as outsourcing, strategy managers, collaborative partners, and information technologies, competitive industries
Competitiveness	Price, quality, dependability, flexibility, responsiveness	Customer happiness, customer wealth, customer safety, and environmental safety
Productivity	Just-in-time, total quality management, business process reengineering, computer-integrated manufacturing, lean production, agile manufacturing and supply chain management	Design for global customer/market, outsourcing, global supply chain, collaborative manufacturing, CRM, and sustainability
Functional	Functional integration through information technology/systems, outsourcing, supply chain management, enterprise resource planning, physically distributed enterprise environment, third-party logistics, activity-based costing and management, knowledge workers	Extended enterprise integration, global supply chain management, ERP II, collaboration marketing, value-based costing and management, strategic workers, virtual enterprise, sustainable and global operations management

therefore, suitable OM curriculum and training programs should be developed.

5.3. Production planning and control

Production planning and control (PPC) is one of the core functions of OM. It aids in resource planning and in utilizing resources to ensure maximum productivity, quality, and competitiveness. Even if companies outsource their parts and components (all materials), the supplier's firm needs to manufacture the products involving all OM functions. However, the basics of OM remain the same. The majority of traditional OM tasks, such as forecasting, aggregate production planning, material requirements planning, capacity planning, scheduling, inventory control, distribution, and quality control, are well-established; they are streamlined and automated with the help of suitable software. For focal companies and partnering firms, PPC has been transformed to outsourcing management. Therefore, the curriculum should be revised to include outsourcing as one of the major functions of PPC.

PPC dimensions should include the following: (1) outsourcing; (2) global planning and scheduling (objectives and constraints may be different from the traditional manufacturing environment); (3) enterprise resource planning for PPC in a network of firms; (4) criteria for scheduling (e.g., minimum inventory and lead time); and (5) productivity of ERP in sharing and using real-time information for formulating PPC decisions. Singhal and Singhal (2007) review the role of Holt, Modigliani, Muth, and Simon's (HMMS) work in the evolution of OM. According to them, the goal of the Graduate School of Industrial Administration at Carnegie Mellon University is to place business education among the fundamental studies in economics and behavioral science. In this paper, the justification for a new OM approach is based on the view that the evolution of OM has been lagging behind that of the society and the market. This may be one of the reasons why US companies, mostly in manufacturing, have suffered from competition and have lost thousands of manufacturing jobs to China, India, and Mexico. The HMMS model (Holt et al., 1960), named after its founders, can be applied to much broader planning rather than to merely aggregate production planning for implementing manufacturing strategy. For example, the model can be applied to make-or-buy decisions (outsourcing), including the selection of suppliers. Finally, the authors conclude that an integrated approach to planning is increasingly becoming common. The approach is unequivocally supported by globalization and the emergence of distributed supply chains.

The HMMS model can be applied to OM. Morgan et al. (2000) analyze the way Japanese multinationals view the future of their UK operations as well as their impact on the organization and management of the parent firms and their subsidiaries. As such, the interrelationship between production facilities and R&D is becoming increasingly important. The HMMS model may not be suitable for a networked and global enterprise operation, but it may be so for the suppliers' firms. Some useful suggestions about the recent contribution of systems thinking to operational research and management science can be found in Mingers and White (2009).

As production planning is usually performed centrally, and control is conducted in a physically distributed enterprise environment, different approaches must be developed and employed. Although the ERP system is utilized for production planning in the focal company as well as in the suppliers' firms, control of production activities is conducted at the suppliers' firm level. Different strategies and tactics must be taught and trained. For example, PPC models and scheduling techniques may use the same criteria, but they need to consider non-financial and strategic performance measures and metrics. Global PPC requires a different focus and criteria for managing global enterprise operations.

5.4. Physical outflow of materials

The physical outflow of products failed to receive earlier significant attention because majority of the buyers and suppliers are local. Therefore, there was no need to be concerned about the long shipping time. In view of the global market and operations, logistics has become considerably more important than ever. This is evident in the way air cargo and third-party logistics (3PL) companies, such as FedEx Corporation and DHL International, flourish in their business. However, current OM does not accord due consideration to this change in the distribution paradigm.

Considering the volume and frequency of products exchanged across the globe in terms of both supply and delivery, logistics has become a critical activity for success. Global logistics involves the use of multimodal transportation services, consolidation, and customs clearing, to name a few. Safety and security are the prime indicators for determining the distribution value chain. Strategic decision involves the usage of 3PL and e-logistics to obtain the best logistics services at a competitive rate. Reverse logistics is becoming increasingly important maintain sustainability in business and operations.

6. Gap analysis among socioeconomic demand, marketing, and OM

This section presents an analysis of the gap among socioeconomic demand, marketing, and current OM function to conceptualize the future OM function. Beyond presenting a mere comparison, a forecast is made on the evolution of markets based on societal evolution and consequently on the new marketing and OM functions.

To understand socioeconomic demand, seven important factors are identified: (i) safeguarding the environment; (ii) responsible supply chain; (iii) fairness; (iv) high standards; (v) human resource skills; (vi) global economic stability; and (vii) respect for human rights.[2] Within these dimensions, an attempt is made to study the gaps in marketing and OM functions.

6.1. Gap analysis between socioeconomic demand and marketing

This subsection analyzes the gap between socioeconomic demand and marketing. The society evolves over time because of changes in the culture and the environment. For example, the Internet has become a common technology tool similar to the radio several decades ago, spurring numerous cultural changes in different communities and countries. Economic growth is linked at all times to certain radical changes in circumstances, such as after World War II and the emergence of the Internet as a medium of communication and a business communications tool.

Spengler (1941) attempts to answer two questions: (1) What constitutes an economic region? (2) What significance do present inter-organizational differences have for the future of manufacturing? Multinational corporations, for three decades serving as the leading actors in an emerging global industrial system, are supported today by increasing competition among countries in terms of economic growth. If their growth and development were to continue, they must respond to both host and home country concerns to achieve a balance. To date, the major driving force behind competition is the efficiency and effectiveness advantage,

[2] Femke de Man, "Tracking the Gap between Societal Expectations of Companies and Perceived CSR (Corporate Social Responsibility) Performance", http://www.globescan.com/news_archives/bcccc_article/

which is commonly called the leverage of multinational vertical system over smaller national horizontal systems (Keegan, 1979).

Current and future socioeconomic demands expect safeguarding the environment first. The marketing function should be tailored to address the needs of the society and transmit information to the OM function. For example, with regard to the environment, companies attempt to trade off environmental implications or pass these on to a different country. The marketing function should convey the needs of the society precisely to OM function. Table 3 illustrates the gap in marketing function in terms of socioeconomic demand or expectations. For example, the lack of customer's knowledge on the product and the complete cycle perspective and process will damage the environment with carbon footprint. Similarly, the high standards of products and processes will satisfy part of the socioeconomic demand. Respect for human rights is crucial in satisfying the aspirations of the society. For example, the lack of understanding of globalization and the market, competition in the global market, and absence of long-term marketing strategy are gaps that exist in marketing with regard to respect for human rights. Other dimensions are listed and are self-explanatory.

6.2. Gap analysis between socioeconomic demand and operations management

This subsection analyzes the gap between socioeconomic demand and OM function. Based on socioeconomic demand, we attempted to identify gaps in the OM function. In Table 3, the third column lists the gaps in the OM function in terms of the environment, responsible supply chain, fairness, high standards, human resource skills, global economic stability, and respecting human rights. In identifying the gaps in OM function, the traditional approach of aligning marketing and OM functions was not followed; rather, socioeconomic demand was examined to determine the gaps in the OM function. For example, a responsible supply chain is met with challenges in the current OM function, including the following: lack of integrated supply chain, lack of commitment to green supply chain, major focus on cost reduction, lack of focus on social welfare and accountability for all stakeholders of the supply chain, and lack of responsible reverse logistics in the e-commerce environment.

6.3. Gap analysis between marketing and operations management functions

The gaps and the possible alignment between marketing and operations are summarized in Tables 3 and 4, respectively. Marketing functions have also evolved to a great extent; therefore, OM should follow.

Based on the analysis performed in previous subsections (Sections 6.1 and 6.2), suggestions are offered (Table 4) to reduce the gaps between the marketing and OM functions along the following dimensions: responsiveness, flexibility, dependability, quality, price, safety, and environmental friendliness. This study proposes new directions for OM functions: collaborative value chain (CVC), responsible supply chain (ResSC), customer satisfaction chain, and global green value chain (GGVC) for enabling responsiveness to socioeconomic demand. Similarly, gaps in marketing function are provided. Aside from proposing new OM techniques and strategies, new marketing functions are also considered to meet the socioeconomic demand. Similarly, to ensure a fair pricing policy across the value chain, the following have been proposed for the marketing function: competitive price, fair pricing, and customer-driven value pricing. Considering

Table 3
Summary of gaps among socioeconomic demand, marketing, and operations management.

Socioeconomic demand	Marketing	Operations
Safeguarding the environment	Lack of customer knowledge on the product, economy-focused, lack of complete life cycle perspective, lack of knowledge of the process and its implications, lack of commitment to customer safety, lack of common understanding of products and their implications	Proactive design and process approach, lack of commitment to protecting the environment, lack of cycle value chain commitment, lack of quality in business process, lack of customer interest in process management, lack of environment consideration in operations and strategies
Responsible supply chain	Misunderstanding of upstream value chain and distribution, life cycle costing, lack of effective reverse logistics, lack of integration of stakeholders along the value chain, lack of adequate training and education on the use and functionality of products	Lack of integrated supply chain, lack of commitment to green supply chain, focus on cost reduction but not social welfare, accountability for all stakeholders of the supply chain, responsible reverse logistics chain, innovative value chain, sustainable operations.
Fairness	Lack of affordable products, quality products, fair pricing policy, misinformation, and unavailability of products for all customers	Lack of fair practices in procurement, lack of employment, lack of assessment, lack of appreciation and rewards, fear of retribution; lack of suitable performance measures and metrics, lack of open communication, lack of transparency and merit-based supplier selection
High standards	Lack of uniform standards for all customers, lack of respect for customers, lack of global standards for fulfilling customer requirements	Lack of quality standards, lack of commitment to produce consistent quality products for all customers in the global market
Human resource skills	Absence of information sharing on products, lack of knowledge on products, lack of knowledge in data mining, lack of strategic thinking in marketing	Lack of quality training, absence of equal opportunities for progression, lack of skills in computers and advanced business process, lack of leadership training, lack of operations strategy, lack of global perspective of operations
Global economic stability	Lack of understanding of globalization and the market, competition in the global market, absence of long-term marketing strategy, global market	Global market and global operations, outsourcing, economic cooperation, joint ventures and subsidiaries, global operations, alignment with local industrial policies, sustainability.
Respecting human rights	Lack of value to human being in terms of marketing products, absence of respect for human rights in global operations, transparency in selling products	Outsourcing of products while respecting international convention and laws, employee empowerment, employee safety and self respect

Table 4
Summary of possible alignment between marketing and operations management.

Performance objectives	Marketing	Current operations	Future operations
Responsiveness	Global market, e-commerce, aftersales service, customer delight, customer satisfaction, customer trust and confidence	Agile manufacturing, supply chain, enterprise resource planning	Collaborative value chain (CVC), responsible supply chain (ResSC), customer satisfaction chain (CSC), global green value chain (GGVC)
Flexibility	Market diversity, customized products and services	Build-to-order supply chain and Internet-enabled supply chain	Customer satisfaction, supplier/partnering firm selection, trust, engaged communication through IT/IS
Dependability	Timely delivery across the globe	Outsourcing, 3PL	Customer schedule, buyer schedule, customer satisfaction-oriented schedule
Quality	Better quality, but for less price	ISO 9000, TQM, six-sigma	Customer value chain quality management, total value chain quality, quality customer value chain
Price	Competitive price	Lean production, and responsive supply chain	Value-based costing approach, value supply chain, customer-driven pricing, strategic value chain (SVC)
Safety	Good customer feedback, ease of use	Design for safety, design for quality	Environment-driven design (EDD), functionality-driven safety design, design for customer-driven safety
Environmental friendliness	Better performance with no harm to the environment	Nanomaterials and less energy consuming process, clean energy fuel	Green customer value chain (GCVC), design for greening value chain (DGVC), life cycle value chain

Table 5
Major factors of emerging operations management function.

Dimension	Major factor	Description
Productivity and competitive strategies	• Globalization • Outsourcing • Global operations • ERP • Strategic alliances with countries • Environment • Terrorism • Energy • Greening • Global warming	The main focus of productivity and competitive strategies should be on global operations, leveraging IT/IS, alliances at the country level, concern over environmental issues and protection against terrorism, sustainability focus, and formation of global consortium for oil and energy resources
Physical inflow of materials	• Global supply • E-procurement • Network of suppliers • Collaboration • Compliance	Physical inflow of materials should focus on global supply management, sustainable operations, and utilize e-procurement and collaborative supply chain
Production planning and control	• ERP • Collaboration with suppliers • Resource exchange scheduling • Project management • Virtual manufacturing	Production planning and control shift more towards managing suppliers and their operations at the tactical level. Project management approach will be suitable for virtual manufacturing
Physical outflow of materials	• Strategic location of operations • Multi-plant operations • Third-party logistics • E-logistics • RFID	Physical distribution should be based on strategic location of plants and markets, multi-plant operations and leveraging third-party logistics and e-logistics as well as RFID technologies

these for the OM function, the following strategies and techniques are proposed: value-based costing approach, value supply chain, customer-driven pricing, and strategic value chain (SVC).

6.4. Major factors of emerging OM function

This subsection discusses the major factors of emerging OM function based on gap analysis and the building blocks for the evolution of OM. Table 5 lists these factors in the major areas of OM. Details of each factor are provided, which form the basis for developing new OM strategies, techniques, tools, and technologies.

The major factors under productivity and competitive strategies should include globalization, outsourcing, global operations, ERP, strategic alliances with countries, terrorism, energy, and global warming. E-procurement, global sourcing, creation of a network of partner firms or suppliers, collaboration, and compliance are among the important factors to be considered under physical inflow of materials. PPC should include ERP, global view of PPC, virtual manufacturing, project management, and resource exchange scheduling. Factors such as strategic location of operations, multi-plant operations, 3PL, and e-logistics form a critical framework of physical outflow of materials.

7. New OM paradigms, techniques, and tools

Based on the gap analysis and subsequent synthesis, a framework is developed for the new OM function considering the current major building blocks of OM. The building blocks should include the following: (1) productivity and competitive strategies; (2) demand management; (3) PPC; (4) supply chain management; (5) ERP; (6) project management; (7) logistics; (8) people management; and (9) support services. Sprague (2007) has edited a special issue called "*Evolution of the field of operations management*" for the Journal of Operations Management, which consists of 16 articles by 26 authors and covers OM topics and issues from the 16th–21st century with predictions for the future. Although the present paper has the same objective, it assumes a different perspective for developing future OM. In the present paper, we did not outline the chronological development of OM because they could be found in various extant articles, including the special edition by Sprague (2007). In fact, this article and the special issue generated our interest in focusing on new OM principles and techniques. As noted earlier, we do not intend to repeat the chronological evolution of OM; thus, those interested in the said subject may refer to Sprague (2007).

7.1. Productivity and competitive strategies

Perhaps many will assume that flexibility entails high cost, but this is not the case. By contrast, flexibility can reduce the cost of production, and the return will be considerably higher than the initial investment on top of a faster payback period. De Meyer et al. (1989) highlight the importance of flexibility as the competitive strategy primarily focused on developing technology and worker skills. Currently, the Japanese are attempting to overcome the tradeoff between flexibility and cost efficiency. Meanwhile, it is time for European and North American companies to focus on cutting costs through agile production. In view of the trust and collaboration between manufacturers and vendors in Japanese companies, American companies should emulate them. The Japanese have heavily invested in automation and expended a considerable amount of time to heighten design and volume flexibility (Watanabe, 1995). This shows the success of the Japanese in productivity. Their competitive strategies can be traced to their success in shop-floor innovation and efficiency.

7.2. Demand management

Demand management has not received due attention from both academics and practitioners. This may be due to the assumption that demand is not under the control of manufacturing and service companies but is driven by external forces. Although this is partially true, demand can be controlled to a certain extent by various marketing strategies as well as alignment with other companies. Recently, CRM has become extremely popular in view of the importance of demand management, allowing the effective management of global and responsive supply chain. For example, Liveris (2006) indicates the importance of the American economy particularly manufacturing, given the high price of energy and the consequences of a weakened American manufacturing industry to global stability. The country must reaffirm its commitment to a robust manufacturing base to assure not only the continued health of its economy but also its continued leadership in the world. The US needs manufacturing, and the world needs the US not only in terms of manufacturing but also in developing new marketing and demand management strategies. Demand management is critical because of the following: (i) competition, (ii) virtual enterprise, and (iii) globalization.

7.3. PPC

PPC in global operations or global supply chain requires strategic and tactical decisions to ensure that supply chain operations are synchronized. The question now is whether traditional planning and control models and techniques can be applied. If not, what type of PPC system would be suitable for the virtual enterprise environment and outsourcing? According to Anonymous (2005), "Within a few years' time, [the] European project [will aim] to have broken new ground in rapid manufacturing and so transform the way some products are made. The scope of custom-fit is to create a fully integrated system for the production and supply of high [value-added] products that are personalised and customised both to fit geometrically and functionally the requirements of the user, and are delivered in hours rather than weeks. This encompasses the whole process from geometry capture through to the design of the product, the simulation of performance, graded rapid manufacturing, and final verification. This is called innovation in design [of the] manufacturer." This indicates an integrated production planning system with design function to facilitate responsive supply chain and therefore meet customer demand as soon as possible. In global supply chain enterprises, PPC is more of a tactical decision. ERP systems can be used for PPC with the objective of minimizing cost of production and responding to customer requirements in a timely manner. Saad and Gindy (2007) present a model for responsive manufacturing that includes the following major factors: (1) product development process; (2) balance response; (3) adaptability; (4) supply network efficiency; (5) change proficiency; and (6) organization characteristics. The criteria used for developing PPC in the global supply chain may differ from traditional enterprises. For example, the HMMS model has to be modified to use a different set of criteria in optimization for a set of new decision-making variables.

7.4. Supply chain management

Supply chain management has been a widely researched and taught subject in recent years in schools of higher learning and has been practiced in firms across the globe. Anonymous (1997) suggests four major elements for success in manufacturing: (a) steady increase in process knowledge throughout the enterprise; (b) learning as a core competency; (c) committed workforce; and (d) ability to use change as a stimulus for growth. World-class manufacturing companies understand their process deeply and manufacture with virtually no disruptions; employ a multi-skilled, continuously trained, and highly committed workforce; integrate seamlessly with suppliers and customers; design and manufacture with a full understanding of the cost savings and environmental benefits of eliminating waste and pollution; move information and production quickly around the globe; leverage technology and capacity; and grow and compete in learning and knowledge as well as in speed, quality, and price. Effective management of a supply chain has been recognized as one of the critical factors in gaining competitive advantage for companies (Christopher, 1998; Kai et al., 2004). Moreover, performance measures and metrics are critical success factors in effectively managing supply chain operations (Gunasekaran et al., 2004). Therefore, students and managers should be taught and trained in Performance Measures and Metrics (PMM) in supply chain operations. Moreover, the role of strategic alliances and virtual enterprise management should be accorded due consideration in the evolving OM curriculum. Gunasekaran and Ngai (2004) discuss the role of IS in supply chain integration and management. They also highlight the importance of the characteristics of global supply chain operations as well as the role of IT/IS in integrating activities.

7.5. Project management

Although project management appears to be a traditional management technique, it has received considerable attention from OM researchers and practitioners. The reason for this is that project management is not only for project-based industries, such as shipbuilding, construction and design, and development of a new jet-fighter or launching a satellite. Even manufacturing has become more of a service industry or project-based industry, where parts and components are produced in different parts of the world and subsequently assembled in different locations. This means that the OM function has become more of a trading of resources in a virtual enterprise environment. Hence, project management has regained its importance in global enterprise environments and operations. Life cycle project management should be deployed towards a proactively responsible supply chain. To satisfy the quality needs of customers, the OM function should focus on customer value chain quality management, total value chain quality, and quality customer value chain. Tavares (2002) contributes operational research to project management. These models are important in view of the role of project

management in the physically distributed enterprise environment and global supply chain operations.

7.6. ERP

ERP has become an integral component of supply chain management. The emphasis on supply chain management and the advancement of information technology created a need for enterprise-wide integration (Yen and Sheu, 2004). It is almost impossible to achieve a well-integrated supply chain without the application of a sound ERP system, particularly in the global operations environment (Yusuf et al., 2004). Pandya et al. (1997) describe the process-based organization and a set of generic process including the following: order fulfillment process, marketing process, support fulfillment process, obtain order process, product and service development process, technology management process, and marketing process. Focusing on these will result in flexible enterprise, total service enterprise, technology leader, and virtual enterprise. Umble et al. (2003) discuss in detail the implementation procedure and critical success factors for ERP systems.

Jacobs and Bendoly (2003) present the implications of ERP in developments and the directions for OM research. Singh and Kasavana (2005) report on the impact of IT on future management of lodging operations; they employ a Delphi study to predict key technological events in 2007 and 2027. The top five reasons for the use of IT (e.g., wireless fidelity or Wi-Fi networks, telemetry links, Bluetooth technology and RFID, commoditization, capacity control, complex distribution channeling, online purchasing channels, data store tools, and expenditure) are as follows: productivity improvement, 42%; enhanced guest services, 25%; revenue generation opportunities, 19.4%; cost reduction/savings, 6.3%; and competitive pressure, 2.6% (Singh and Kasavana, 2005). Therefore, students and employees should be taught and trained not only on the usage of ERP systems but also their strategic implications in managing a 21st-century enterprise environment.

7.7. Logistics

The profile of logistics has changed quite radically during the past decade mainly because of the global market and e-commerce. Earlier companies used to assume all the necessary functions from marketing to sales. Nowadays, companies stay focused on their core competencies and outsource non-core business processes. This situation has provided opportunities for 3PL and e-logistics to emerge, which have seen tremendous business growth (Marasco, 2008). Air cargo will continue to play a major role in global logistics operations. Therefore, suitable air cargo operations, including sea transport, need new models for managing resources productively to ensure the right materials can be made available at the right place and in the right quantity. Optimization models, such as transshipment models, network flow problems, transportation optimization, and global scheduling problems, may be more appropriate for the current enterprise operations.

7.8. People management

Unfortunately, the issue about people has not been accorded due attention in traditional organizations. The issue of people management, including hiring and training, in a physically distributed and global enterprise environment is considerably more challenging than ever before. A flexible and knowledge-based workforce is required for ensuring competitiveness and managing business successfully in a global market. Characteristics of the workforce in the so-called global supply chain include the following: adequate education, knowledge in computers, familiarity with ERP, multilingualism, and strategic thinking.

7.9. Support services

Support services, such as IS/IT, logistics, and environmental compliance, are equally important for the effective management of global supply chain or virtual enterprises. As the majority of support services are outsourced, judicious planning and control of outsourcing of support services for integrated global supply chain operations are critical. The environmental impact of manufacturing must be assessed at the global and local scale. The industrial materials cycle captures the flow of materials from the natural environment through the manufacturing and use components of a product life cycle, accounting for remanufacturing, recycling, and disposal back to the environment. Durham (2002) suggests that environmental management of the cycle of total materials must provide tools for evaluating the effect of changes in processing or materials substitution on a global basis, where materials use and reuse, component remanufacturing, and materials recycling can consider the overall cost and the impacts can be assessed.

Bayraktar et al. (2007) highlight a number of the new features of the work system characteristics in OM, which include ERP, CRM, SCM, and knowledge management (KM). They also present the characteristics of future organizations, including the following: e-business, Internet, e-market places, data warehousing, environmental consciousness, quick response systems, efficient customer response systems, ethics, CRM, and data mining. Political and ethical concerns in terms of production and sale of goods and services become an inevitable part of marketing strategies. Moreover, they indicate that new systems of performance measures, collaborative commerce and advanced IT, forecasting, operations strategies, service OM, and supply chain risk management are essential for new OM.

As overhead is significant in virtual enterprise and global supply chain environments, it requires a model or cost accounting system to determine the overhead involved and how it can be reduced to enhance supply chain operations. This is geared not only towards teaching and training students and employees on ERP systems but also towards instituting appropriate performance measures and metrics, such as cost accounting systems.

8. OM curriculum development and industrial practices

In view of the evolution of market and operations, now is the time to revisit the curriculum and industrial practices of OM. Future OM curriculum should include the following modules: global marketing, global operations, enterprise resource planning, global logistics, virtual enterprise, risk management, production planning and control in global supply chain, operations research in global operations management, value-based costing, multinational finance, e-commerce, e-banking, human resource management in global supply chains, security and global operations, outsourcing, culture and business management, and global supply chain management. Industrial experience should be part of the OM curriculum, and this may be in the form of a dissertation or major project in the areas of supply chain and ERP, among other topics (Pal and Busing, 2008).

Based on the evolution of marketing, industrial practices and training should focus on the following:

- International markets and operations
- Global logistics
- ERP and e-commerce
- Strategic formulation, implementation, and control
- Outsourcing

- Demand management
- 3PL
- Virtual enterprise development and management
- Resilient supply chain
- Small and medium enterprises in global supply chain
- International production planning control
- Sustainable operations management and business development

9. Modeling and analysis of future operations management

In this section, we look at the applications of various operations research and management science models in the future operations strategies, techniques, and operations. Since the main focus of this paper is to identify the future operations function, we have limited our discussion on modeling and analysis of future operations management function. We hope this will be our next project once we see the reaction to the current paper. However, based on the previous literature reviews and our own experience in the field, we have summarized the potential operations research and management science models as shown in Table 6. We believe future researchers should explore the application of the models in both manufacturing and non-manufacturing settings.

There are number of operations research and management science models which could be used to model the future operations management function. For example, Lim and Tan (2010) model an aspect of supplier opportunism in outsourcing using game theoretic models. Ouhimmou et al. (2008) study the supply chain tactical planning (procurement, inventory, outsourcing, and demand allocation policies) optimization using a time decomposition approach. They have formulated the planning into a large mixed-integer programming model and subsequently developed heuristics using a time decomposition approach in order to obtain good solutions.

Yildiz et al. (2010) present an integrated study of inbound logistics from suppliers and the outbound logistics to customers. They have modeled the supply chain coordination problem from the perspective of transportation arrangements using a mixed-integer programming model that matches opposite flows from and to the customers and suppliers. Toptal (2009) studies the replenishment decisions by formulating a Newsboy problem considering several scenarios that model the costs for buyers and vendors. The model takes into account all the costs and benefits associated with discounts, transportation, and cargo capacity.

Recent years, reverse logistics has received a significant attention after the emergence of sustainable operations and business development both in services and manufacturing. In order to support the decision making in reverse logistics, operations researchers and management scientists developed models using vehicle routing optimization models. For example,

Table 6
Modeling and analysis of emerging operations management function.

Dimension	Major functions	Decisions	Operations research and management science models
Productivity and competitive strategies	• Globalization • Outsourcing • Global operations • ERP • Strategic alliances with countries • Environment • Terrorism • Energy • Greening • Global warming • Sustainability	• Risk assessment in globalization • Outsourcing (make or buy decisions) • Life costing and optimization • Implications for energy risk management • Optimization of reverse logistics • Modeling of greening decisions in supply chains	• Multi-criteria decision models • Total cost and benefit models • Risk assessment models • Fuzzy-AHP integrated IT/IS justification models • Resource allocation models • Game theory models • Linear programming models • Agency theory and employment contracting models • Transfer pricing models • Network flow models • Real option analysis • Continuous approximation models • Decision tree models
Physical inflow of materials	• Global supply • E-procurement • Network of suppliers • Collaboration • Compliance	• Optimization of supply chain configuration • Evaluation of the outcome of collaboration • Implications of risks due to non-compliance • Logistics cost minimization	• Network models • Fuzzy-AHP models • Inventory models • Transportation models • Simulation models • Linear/non-linear programming models
Production planning and control	• ERP • Collaboration with suppliers • Resource exchange scheduling • Project management • Virtual manufacturing	• Justification and measurement of ERP in SCM • Resource optimization • Optimal scheduling • Project management • Optimization of virtual manufacturing • Cost minimization	• Scheduling models • Inventory models • PERT/CPM • Forecasting models • Queuing theory and models • System dynamics
Physical outflow of materials	• Strategic location of operations • Multi-plant operations • Third-party logistics • E-logistics • RFID	• Optimal location of partners or suppliers • Optimization of multi-plant operations and markets • Optimization of 3PL • Evaluation of the impact of RFID on SCM	• Systems analysis models • Assignment models • Transportation models • Systems theory models • Total cost and benefit models • Network flow optimization models • Inventory models • Scheduling models

Repoussis et al. (2009) develop a decision support system (DSS) to support the schedulers in managing reverse supply chain management problems effectively by integrating ERP system. Santos et al. (2010) present a linear programming model for sustainable vegetable crop supply problem.

Outsourcing is an integral component of future operations strategy. The subject has received significant attention from both researchers and practitioners. However, this subject poses a great challenge in modeling and analysis of outsourcing decisions. One of the latest papers on outsourcing decision modeling is by Tjader et al. (2010) which deals the best governing policy for offshore outsourcing of business activities using analytic network process (ANP), a multi-criteria decision making methodology for evaluation. Osei-Byrson and Ngwenyama (2006) develop a risk assessment model using incentive contracts for information systems management and outsourcing.

Table 6 lists some potential operations research and management science models for the future operations functions and decisions. For example, at the productivity and competitive strategic areas, decisions such as risk assessment, make or buy decisions, life cycle costing analysis, and models for green supply chains and optimizing 3PL operations can use models such as multi-criteria decision, risk assessment, fuzzy-AHP integrated approach, game theory, linear programming, agency theory and employment contracting and network flow models. For physical inflow of materials, optimal supply chain configuration, assessment of the outcome of collaboration, risk assessment and logistic cost minimization would employ models or techniques such as network flow problems, fuzzy-AHP, inventory control, transportation, simulation and linear and non-linear programming. Production planning and control decisions involve balancing the capacity with demand, scheduling, optimal lot size, and process control. These could use scheduling techniques, inventory models, PERT/CPM, forecasting, simulation, and queuing theory and models. Physical outflow of materials deal with decisions such as optimal location of distribution centers, outsourcing partners, scheduling, inventory control, warehousing operations systems, transportation and logistics. For these, we could employ transportation problem, assignment method, systems theory, queuing models, total cost and benefit models, network flow optimization, inventory and scheduling models.

10. Summary of the findings and conclusions

In this paper, an attempt is made to study the evolution of OM. Considering the evolution of marketing and society over the years, there is a need to revisit the OM function. Although a significant number of articles have discussed the evolution of OM, the present study takes a different approach – an integrative one – that also considers the evolution of the society and the market. By carefully identifying the gap between marketing and production, the need for a new direction in OM has been suggested. A framework for new OM is proposed with the objective of providing a suitable direction for developing a university curriculum as well as for training and developing the skills of employees in practice. Also, suggested some modeling and analysis techniques for the future operations management functions.

Moreover, this study provides a concept of new OM function that considers the radical change in enterprise environment, including market and social evolution. That IT/IS has changed the way companies operate and people function in their day-to-day work and life is indisputable. Nevertheless, focus is placed not only on IT/IS in OM but also on the implications of economic cycle and the increasing price of energy that emerging large economies have contributed to the globalization of markets and operations. In the past, empirical research mostly delved into such topics as operations strategy, technology management for operations, quality management, and so on; there was a dearth of research on energy and environmental and compliance issues. Therefore, future research directions should include an empirical validation of the proposed model for the new OM function.

Without a doubt, looking at China's success in manufacturing and its increasing importance in the global economy will be a good lesson for other countries, encouraging them to learn from the Chinese experience and recognize the importance of manufacturing. Service continues to play a major role in the knowledge economy as reflected by the increasing GDPs of countries around the world. Although manufacturing may reasonably be associated with the desirable phenomena of high living standards, personal independence, and sophisticated forms of employment, as well as of employment in technical development and production, competence in manufacturing is a necessary yet insufficient condition. Focus on manufacturing is considered much more than service and trading, with generally more successful factor-driven, investment-driven, and innovation-driven factors (Currie et al., 1997).

Souza et al. (2006) argue that virtual manufacturing is the way to go for the factory of the future. Virtual manufacturing represents an emerging approach that enterprises can utilize to improve their processes and introduce new products more quickly in a cost-effective manner. The fundamental idea is to create an integrated and synthetic environment composed of software tools and system, such as virtual reality and simulation, to support such processes. Gupta et al. (2006), in their review paper on empirical research published in Production and Operations Management Journal between 1992 and 2005, recommend that more research should be conducted in service OM interfaced between operations and other functional areas. They state that the future is full of promise with new areas emerging, such as global manufacturing and service networks, dynamic pricing and revenue management driven by the digital economy, new technologies such as RFID, closed-loop supply chains and sustainable operations, and the increasing role of services in the economy. Further, they propose two additional areas of research: (i) behavioral issues and (ii) revenue management in OM. Meanwhile, Mehrabi et al. (2000) suggest that the key to future manufacturing is reconfigurable manufacturing systems. Gunasekaran and Ngai (2009) offer a number of directions for future research on modeling and analysis of build-to-order supply chains. For his part, Stadler (2005) discusses certain challenges in supply chain management.

Service management is critical in virtual enterprise and outsourcing environment, including manufacturing industries. Virtual enterprises are based on core competencies, and thus manufacturing has become more of a service. The OM curriculum should be developed to promote skills in building a network of enterprises based on dynamic markets, develop strategic alliances based on core competencies, leverage the role of information technology and systems, and recognize the fact that the market and the operations have become global. Hence, school curriculum and industrial training programs must be developed to impart the following:

- Global perspectives
- Global market and operations
- Appreciation of global multiculture and language
- Significance of servitization
- Role of ethics in business
- Implications of technology in business
- Sustainable operations and business development
- Importance of logistics and its infrastructure
- Balanced growth of manufacturing across the globe

These areas require further development to formulate a suitable OM curriculum and related training programs.

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