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Build-to-order supply chain management: a literature review and framework for development

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Abstract

The build-to-order supply chain management (BOSC) strategy has recently attracted the attention of both researchers and practitioners, given its successful implementation in many companies including Dell computers, Compaq, and BMW. The growing number of articles on BOSC in the literature is an indication of the importance of the strategy and of its role in improving the competitiveness of an organization. The objective of a BOSC strategy is to meet the requirements of individual customers by leveraging the advantages of outsourcing and information technology. There are not many research articles that provide an overview of BOSC, despite the fact that this strategy is being promoted as the operations paradigm of the future. The main objective of this research is to (i) review the concepts of BOSC, (ii) develop definitions of BOSC, (iii) classify the literature based on a suitable classification scheme, leading to some useful insights into BOSC and some future research directions, (iv) review the selected articles on BOSC for their contribution to the development and operations of BOSC, (v) develop a framework for BOSC, and (vi) suggest some future research directions. The literature has been reviewed based on the following four major areas of decision-making: organizational competitiveness, the development and implementation of BOSC, the operations of BOSC, and information technology in BOSC. Some of the important observations are: (a) there is a lack of adequate research on the design and control of BOSC, (b) there is a need for further research on the implementation of BOSC, (c) human resource issues in BOSC have been ignored, (d) issues of product commonality and modularity from the perspective of partnership or supplier development require further attention and (e) the trade-off between responsiveness and the cost of logistics needs further study. The paper ends with concluding remarks.

Keywords: Build-to-order supply chain management; Literature review; Framework

1. Introduction

The global nature of the markets and competition has forced many companies to revisit their operations strategy. Companies have moved from centralized operations to decentralized operations in order to take

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advantage of available resources and to be closer to their markets. Consistent with this, firms have undergone numerous changes in terms of strategies, tactics, and operations with the aim of meeting the changing requirements of the market. Currently, companies have to compete based on multiple competitive performance objectives such as quality, price, responsiveness, flexibility, and dependability.

Mass customization has become a major objective of many Fortune 500 companies. Towards this end, firms have developed a build-to-order supply chain (BOSC) to be flexible and responsive. Recently, BOSC has become a popular operations paradigm after the success of its implementation in Dell Computers, BMW, and Compaq. To achieve mass customization, the BOSC model is now being actively pursued in several different industries. One of the first successful build-to-order (BTO) companies was Dell Computers, which gained market share by building customized computers using the Internet as an order fulfillment vehicle. In addition to Dell, BMW also allows customers to make changes to their vehicle within 6 days of final assembly (including a complete change in color, etc.). This allows BMW to build up to 550,000 permutations of the Z3 vehicle.[1] Agility (flexibility and responsiveness) has become a competitive weapon for capturing market share in a global market where products are sold and bought online. Also, Internet technologies have changed the dimension of enterprise operations and management. Companies rely on strategic alliances based on core competencies and information technologies to achieve flexibility and responsiveness in their supply chain.

Today's market environment is characterized by diverse customer tastes and preferences, rapid developments in technology, and the globalization of management (Hsu and Wang, 2004). These factors have led to the need to offer a variety of products, which presents major challenges to production managers. In order to overcome the difficulties posed by a proliferation of products, there has been an increasing emphasis on redesigning products and processes to ameliorate the possible negative impact of offering a large variety of products. Designing to defer product differentiation is a strategy whereby the final configuration of a product is postponed as much as possible, usually until a customer's order is received (Lee and Tang, 1997). Dell and Gateway have developed a BOSC to capture the variability of demand in the PC industry, recognizing the distinct characteristics and the volatile and difficult-to-predict demand for high-technology products (Hsu and Wang, 2004). An example of a successful BTO is Fujitsu's establishment of a configuration center to precede the final assembly of products in Tennessee. Compaq, for its part, has simplified the structure of its products, and reduced the complexity of its product mix to enhance the implementation of BTO. These moves indicate that several companies have made good progress in implementing BOSC. A BOSC production system has different requirements than are found in standard mainstream production operations. Additional requirements for a BTO system include ending the day with empty tables (no work-in-process), maintaining zero inventories on finished goods, and building products to order only (Wagner et al., 2003).

Apple Computer was unable to fill orders for its new high-end line of G4 computers because of delays in the supply of chips. As a result, the company experienced a devastating 14% drop in revenue in 1999. Apple was able to address these delays and respond to them by managing suppliers and optimal production schedules. On the other hand, Dell Computers proved that Internet-based mass customization is the preferred business model (BOSC) – and the most profitable one – in the PC industry. Dell generated a 160% return on its invested capital by allowing customers to build their own computers online, then successfully manufacturing and delivering these computers with a lead time of 5 days for the delivery of the products (Ghiassi and Spera, 2003).

There have been a number of research reports and magazine articles on BOSC. However, there is some confusion in these writings between make-to-order (MTO) and BTO. The lead times are longer in MTO than in BTO. In MTO, components and parts are made and then assembled. In the case of BTO, the components and parts are ready for assembly. There are a noticeably limited number of research papers on BTO from both academics and practitioners. Nevertheless, BTO is gaining ground not only in selected industries, but across all types of industries. Therefore, considering the importance of BOSC, a review of the

[1] Professor Robert Handfield, Editor-In-Chief, Journal of Operations Management, 2003.

literature was carried out with the aim of describing the concept of BOSC and developing a framework for the development of BOSC. Also, some future directions for research on BOSC are highlighted.

The aim of this paper is to contribute to the evolution of strategic and organizational thinking for BOSC by presenting work that is well grounded in theory and evidence (qualitative and quantitative analysis); relevant, accessible, valid, and useful to both managers and academics. It is also to demonstrate the managerial implications of the BOSC concepts and applications using the previous concepts.

The paper is organized as follows: Section 2 discusses BOSC. The details of the research methodology are presented in Section 3. Section 4 presents the classification scheme used for reviewing the selected literature on BOSC. A brief review of the literature on BOSC is presented in Section 5. A framework for developing BOSC is developed in Section 6. Finally, conclusions are presented in Section 7.

2. Build-to-order supply chain management (BOSC)

Due to increasing global competition and a decline in profit margins, most multinational corporations are pursuing different operations strategies to secure market share and improve profits. Specifically, BOSC and configure-to-order (CTO) markets driven by mass customization and e-commerce are forcing retailers and manufacturers to shorten planning cycles, compress manufacturing lead times, and expedite distribution (Tyan et al., 2003). In this section, some case experiences and various definitions and strategies of BOSC will be discussed. As discussed earlier, Dell has developed flexible manufacturing techniques that allow the company to virtually build computers to order. To support this MTO strategy, the company runs a lean manufacturing operation. By working closely with suppliers, inventories of components and materials are minimized. Dell's close relationships with its suppliers have allowed the company to operate with nearly no work-in-process inventory. Building systems to order means that there is no finished product inventory in the channel to manage (Bowersox et al., 1999).

Based on the studies of Olhager and Ostlund (1990), the manufacturing continuum can be classified as make-to-stock (MTS), assemble-to-stock (ATS), make-to-order (MTO), and engineer-to-order (ETO). Their study claimed that build-to-forecast (BFT) is similar to MTS and ATS; BTO is similar to MTO; and CTO is similar to engineer-to-stock (ETS). BTO/CTO production systems aim to quickly meet the diverse demands of customers. However, the BTO system relies strongly on the tight integration of the upstream supplier of parts, the midstream manufacturer and assembler of components, and the downstream distributor of finished goods in the supply chain (Chen et al., 2003).

BOSC as a strategy can be defined as "the value chain that manufactures quality products or services based on the requirements of an individual customer or a group of customers at competitive prices, within a short span of time by leveraging the core competencies of partnering firms or suppliers and information technologies such the Internet and WWW to integrate such a value chain."

BOSC provides a level of responsiveness, cost effectiveness, and flexibility that enables companies to deliver the products that customers have chosen at the time they requested it. This chain reduces the dependence on forecasts, batches, inventory, or working capital. BOSC results in substantial cost advantages by eliminating the inventory, forecasting, expediting, and setup required to customize products or services. BOSC helps companies utilize people, machinery, and floor space more efficiently (http://www.bourtongroup.com/bo_core.htm). BOSC allows a manufacturer to react on time with the market and even shape the behavior of the market. This requires real-time information flow and responsiveness among partners in order to achieve whole system optimization (Waller, 2004). BOSC does not allow inventories of finished goods in the system as it pulls the materials through the value chain based on customer orders. This is similar to MTO or assemble-to-order (ATO), but the difference is in the outsourcing of different parts and services based on the core competencies of partnering firms. BOSC is oriented from a one-of-a-kind paradigm, but is based on a pre-determined variety. BOSC can be utilized to manufacture a low volume of products of a pre-determined high variety using a cluster of components.

Table 1 illustrates the differences between traditional SCM (TSCM) and BOSC by considering the

Table 1
Differences between traditional and build-to-order supply chains

Reference	Traditional supply chain	Build-to-order supply chain
Marketing	Push—sell from stock	Pull—build to customer order
Production	Focus on level and stable schedules: fixed order lineup	Customer demand focused on supply chain flexibility
Logistics	Mass approach—non-differentiated	Fast, reliable, customized
Customer relationship	Dealer-owned	Shared across the extended enterprise
Managing uncertainty	Finished goods inventory buffers	Strategic part buffers and information management
Finished goods inventory	High stock control	Low, condensed dealer stock levels
Suppliers	Long lead times	Collaborative/responsive

Source: Deloitte Consulting (2003).

major functional areas (marketing, production, and logistics) and major operations issues (customer relationship management, managing uncertainty, finished goods inventory, and supplier development). TSCM satisfies customer requirements from stock using the MTS system, but BOSC builds the products based on orders from customers. In TSCM, the focus is on a stable production schedule with deterministic demand, but in BOSC it is on customer demand and supply chain flexibility. Logistics is tailored to the delivery requirements of individual customers in BOSC, but in TSCM the focus is on consolidation and a mass approach. The customer is an integral part of BOSC, but in TSCM the concern is more on the requirements of the dealer. In TSCM, the managing of uncertainty is based on the stock of finished goods and on a buffer, while in BOSC uncertainty is handled by having components as a buffer and through information management. TSCM operates on longer lead times for delivery from suppliers, while BOSC operates using a collaborative and responsive approach.

TSCM is similar to MTS. However, TSCM and BOSC differ in their level of flexibility and responsiveness to changing market requirements. TSCM is based on a long-term relationship with suppliers and customers in the buying and selling of products. TSCM is a push system, but BOSC is a pull system, where materials are pulled through the system based on customer orders. TSCM can be local, but BOSC must be global, considering the implications of ordering products using the Internet. Since BOSC is a global chain, this requires a different management approach than TSCM. For example, the two systems vary in their selection of partners and in the criteria that they use. In BOSC, logistics plays a major role in determining the partnering firms including the location of their assembly plant. The main objective of BOSC is to: (i) determine the optimal product mix based on the demand for products, (ii) determine the optimal point of product differentiation along the value chain (customer order decoupling point), (iii) optimize the cost of logistics, and (iv) develop a suitable architecture for the organization and for information systems. BOSC is for high-volume manufacturing companies such as Dell and BMW, and is based on the customer order de-coupling point (CODP) between MTO and ATO, supported by new technologies that are fast and flexible. It must be noted that each business unit within the SC may have its own CODP and that, in this case, the whole SC is not a BOSC.

BOSC can be defined from the perspectives of concept and process. In terms of concept, BOSC can be defined as the configuration of forms and capabilities in the supply chain that creates the greatest degree of flexibility and responsiveness to changing market/customer requirements in a cost-effective manner. BOSC is flexible and responsive because it incorporates certain characteristics of agile enterprise/organizations. An interesting issue is how to resolve the conflict between the principles of lean manufacturing (long stable runs, stable schedules, etc.) and those of the BOSC model, which require short runs, customer responsiveness, and unstable schedules. The situation of uncertainty (instability) in BOSC can be eliminated by developing suitable strategic alliances and leveraging people and information technology including knowledge and enterprise information system management. From the process

perspective, BOSC can be defined as "a value chain that activates the processes of building the products based on individual customer requirements and by leveraging information technology and strategic alliances with partnering firms for required components and support services such as logistics. The aim in BOSC is to meet the demands of individual customers with a short lead time and minimum inventory and production costs along the value chain."

In BOSC, the handling of uncertainties is addressed by a real-time information sharing system and appropriate partnership selection (strategic alliances) and development. Also, the partners or suppliers are expected to carry some inventory of parts and components. On the other hand, TSCM requires buffers of materials to manage the uncertainties, although a quality service is expected from suppliers. Compared to TSCM, the capacity of BOSC has a greater impact on the throughput rate of the system. However, the major uncertainties between the two environments will differ considering the nature of the demand for products. This leads to further nervousness among supplying firms or partners.

The characteristics of BOSC are rather different. BTO enables manufacturers to accept new orders during production. A customer can place an order that results in an exact product based on the customer's individual requirements. This takes into consideration production scheduling and delivery time. It the BTO phase is to be successfully implemented, demand-management techniques must be taken into consideration to manage fluctuations in volume. Such techniques include marketing incentives, pricing strategies, and increased flexibility with suppliers, all of which help to balance supply with demand and allow the pipeline to change right along with the demands of the consumers.[2] This implies the significance of managing demand. Most companies assume that they do not have any control over demand. However, demand can be managed by exercising control over prices, promotional efforts, and the quality of the services offered.

Building to order enables manufacturers to better respond to market conditions. The time lost between changes in customer preferences and product mix disappears, and customer demand can be both anticipated and shaped by the sales system. An automotive BOSC must be able to meet seasonality within markets, and understand the detailed volatility in the demand for certain elements of the complex product-mix, from which much of the profitability is derived. Market-responsive manufacturing entails production and supply capabilities that are adaptive and flexible, in conjunction with real-time market interaction through revenue management (Waller, 2004).

The opportunity to ensure that the production system is efficiently utilized is reduced due to the BTO approach, which is most often associated with a strategy of customization. The problem is that the techniques of traditional industrial production can only be applied to a limited extent in BTO (Steger-Jensen and Svensson, 2004). Manufacturers have applied a mass customization approach, in which products are specified for the individual customer and are subsequently built to order. By using this approach it is possible to adapt the product to fit a very wide range of customers, without maintaining excessively large inventories. However, the following problems tend to be characteristic of BTO: order-processing is time consuming and costly, multiple revisions of specifications are required, delivery dates are often not met, last-minute changes take up an increasing portion of resources, production plans are often inaccurate and over-ruled, and the more often this happens, the more profits decline.

Unlike the TSCM, BOSC will have global operations, which further require addressing the issues of exchange rates, taxes, political stability, the resources and capacity of the assembly line, etc. BOSC is based on a collaborative and responsive approach utilizing shared information systems such as enterprise resource planning (ERP) and B2B e-commerce. This could be realized by selecting the right partners and making use of various information technologies. The challenges of uncertainty in a supply chain both from the supply and demand side should be addressed in BOSC. For example, on the demand side, it difficult to estimate the number of customer orders expected over a given period of time. Perhaps, demand management could be used to control the number of incoming orders. On the supply side of BOSC, partnering firms not sure what and how

[2] http://www.deloittee.com/dtt/article/0,2297,sid%3d265551%26cid%3d42003,00.html, 17 June 2004.

much of different components and parts to keep in inventory so that they can provide better services to their clients or buyers. Logistics is another important area in BOSC to be investigated with the aim of delivering the products to customers on time.

Responsiveness and flexibility are the key objectives of BOSC. However, it has its own limits with regard to the level of speed and flexibility in responding to changing customer requirements. For example, modularity based on the commonality of component parts still plays an important role in BOSC. The number of partnering firms increases as a higher level of responsiveness and flexibility is required. Since most of the component parts and logistics services are outsourced, there is a need to develop responsibility and flexibility in the supplier firms by forming suitable strategic alliances based on core competencies and an integrated enterprise information system.

To achieve BOSC, companies need to invest large amounts of money to redesign internal organizational and technical processes, change traditional and fundamental product distribution channels and customer service procedures, and to train staff. Based on an analysis of various concepts of BOSC and comparing its characteristics with those of TSCM, it can be said that the main focus in BOSC is on meeting individual customer requirements through the flexibility of products, without compromising on cost, quality, and responsiveness; and, with the help of modularity, delaying product differentiation and the leveraging of information technology to achieve an integrated network of suppliers or partnering firms. Having discussed the concepts, definitions, benefits, and limitations of BOSC, this paradigm offers great scope for improving organizational competitiveness in a global market. In the following sections, we briefly discuss our research methodology and review the literature on BOSC using a suitable classification scheme.

3. Research methodology

A literature survey was employed as the research methodology in the study to develop a framework for BOSC. The literature on BOSC was collected primary from journals in the areas of operations management, supply chain, operations research, and information systems. For the sake of rigorousness, dissertations, textbooks, unpublished working papers, and conference papers were excluded. In addition to classifying the literature on BOSC, the tools used to model and analyze various BOSC environments are also presented. This will be useful to researchers interested in modeling and analysis. The literature search included journals published by numerous publishers, in particular Elsevier, Emerald, and Taylor and Francis, together with journals such as Management Science and Operations Research.

The primary aim of the literature search was to help researchers and practitioners develop an effective BOSC. The literature on BOSC and some associated references were classified according to this objective and are reviewed in the following sections.

4. Classification of the literature on BOSC

We found several review articles on supply chain management, but none on BOSC. For example, Croom et al. (2000) provided an analytical framework for a critical review of the literature on TSCM. This framework includes a classification of SCM literature that is both content-oriented and methodology-oriented. They listed the principal components of supply chain literature, such as strategic management, logistics, marketing, relationships/partnerships, best practices, and organizational behavior. Vidal and Goetschalckx (1997) presented an extensive review of strategic production–distribution models. They classified the literature into four sections: previous reviews, optimization models, additional issues for modeling, and case studies and applications. However, their review is restricted to mixed integer programming models. Tan (2001) provided a framework along the following lines: (i) the purchasing and supply perspective of industrial buyers, (ii) the transportation and logistics perspective of merchants, and (iii) the unified/integrated supply chain management strategy. Other related review papers include those by Maloni and Benton (1997), Minner (2003), Goetschalckx et al. (2002) and Grieger (2003). These reviews primarily focus on modeling and analyzing traditional supply chain management. It should also be noted that the models that have been reviewed mostly deal with inventory, location, and transportation problems. We

found no review paper on the modeling of BOSC, although some TSCM models can be used. However, the objectives of the optimization and decision variables may be different.

The literature available on BOSC is reviewed here with a focus on organizational competitiveness, strategic planning, design, and operational issues. These issues have not been systematically addressed by researchers and practitioners. The literature on BOSC is classified into the following four major areas considered essential to developing and managing BOSC, based on the nature of decision-making: (1) BOSC and organizational competitiveness, (2) the development and implementation of BOSC, (3) the operations of BOSC, and (4) BOSC and information technology. The details of each classification are discussed in the next section. Following an analysis of the literature, the following were identified as key factors in developing BOSC: the external factors that influence a company's performance and the decision to adopt BOSC; design and development strategies and tactics for BOSC; the planning and control of BOSC operations; and the implications of information technology on BOSC. The objective of this paper is first to identify the differences between traditional and build-to-order supply chain management (see Section 2). Second, how the implications of various factors in the above decision-making areas differ between BOSC and traditional supply chain management will be discussed. Finally, a framework for developing a BOSC is presented. The details of the major classification scheme and the articles that come under each such classification are presented in Table 2.In order to be more precise and identify the detailed areas for developing and managing BOSC, the studies in the four major areas have been further classified into detailed decision-making areas, as shown in Table 3. The area of BOSC and organizational competitiveness includes the implications of external factors or environmental factors on BOSC; that is, economic factors, market forces, and competitive factors. The second area, developing and implementing BOSC, includes design and procurement, partnership and virtual enterprise, logistics, and the implementation of BOSC. The third area incorporates criteria such as planning/forecasting, coordinating, and monitoring. Finally, the fourth area is BOSC and information technology. Some major kinds of information technology for BOSC are the Internet, e-commerce, ERP, and radio frequency identification (RFID).

5. Review of previous research on BOSC

In this section, the studies available on BOSC (mostly in the form of journal articles) are reviewed for their application and development based on the classification scheme discussed in the previous section.

5.1. BOSC and organizational competitiveness

While developing BOSC, it is very important to consider the factors that force companies to develop a build-to-order supply chain. For example, Dell Computers has developed a supply chain that uses the Internet as a medium for placing orders to meet the requirements of individual customers. Factors external to an organization such as general economic conditions, inflation, political stability, industrial policies, wage rates, and so forth influence the strategies of a business organization. These factors should be taken into account while developing strategies for BOSC.

5.1.1. Economic factors

In many instances, companies fail to achieve long-term prosperity due to poor strategic planning. For example, many companies fail to develop a suitable supply chain that takes into account general economic conditions, currency value, inflation, and wages. Yet, as survival and prosperity are very important for any organization, companies must develop long-term strategies. For instance, interest and currency exchange rates have an impact on the economy and influence the demand for and characteristics of products on the market. A poor economy means that people have less money to buy goods and, therefore, may go for standardized products with price as the main concern. Companies can develop their supply chain accordingly. Considering the agile characteristics of the economy, a more agile organization such as BOSC would be more suitable in helping a company compete not only in terms of service quality, but also in terms of the timely fulfillment of orders.

Innovation is not simply a technical-rational process of ''solving problems''; rather, the sociology

Table 2
Classification of the literature available on BOSC

Classification criteria	References
BOSC and organizational competitiveness	Porter (1980, 1995), Shapiro (1989), Daugherty and Pittman (1995), Sonntag (2000), Papazoglou et al. (2000), Dedrick et al. (2001), Jarratt and Fayed (2001), Walters and Buchanan (2001), Carayannis and Sagi (2001), Childerhouse et al. (2002), Hult (2002), Lei and Slocum (2002), Pearce (2002), Prastacos et al. (2002), Alessandri and Bettis (2003), Holweg and Miemczyk (2003a, 2003b), Jelassi and Leenen (2003), Tse and Soufani (2003) and Waller (2004)
Development and implementation of BOSC	Bhattacharya and Coleman (1994), Lee (1996), Bowersox et al. (1999), Jahnukainen and Lahti (1999), Cravens et al. (2000), Graham and Hardaker (2000), Pawar and Driva (2000), Vrijhoef and Koskela (2000), Forza and Salvador (2002), Kraemer and Dedrick (2002), Morris and Morris (2002), Muffato and Payaro (2002), Power and Sohal (2002), Svensson and Barford (2002), Thonemann and Bradley (2002), Van Tulder and Mol (2002), Weber (2002), Chopra (2003), Davila et al. (2003), Erhun and Tayur (2003), Skjott-Larsen et al. (2003), Ghiassi and Spera (2003), Holweg and Miemczyk (2003a, 2003b), Swaminathan and Tayur (2003), Tyan et al. (2003), Biswas and Narahari (2004), Brunn and Mefford (2004), Chung et al. (2004), Hsu and Wang (2004), Partanen and Haapasalo (2004), Power and Simon (2004), Teich et al. (2004), and Naylor et al. (1999)
Operations of BOSC	Banker and Khosla (1983), Glasserman and Wang (1998), Krause et al. (1998), Chen et al. (2000, 2003), Griffiths and Margetts (2000), Kolisch (2000), Hegedus and Hopp (2001), Childerhouse et al. (2002), Muffato and Payaro (2002), Song and Yao (2002), Geunes (2003), Iyer et al. (2003), Wagner et al. (2003) and Biswas and Narahari (2004)
BOSC and information technology	Ollivier (1995), Graham and Hardaker (2000), Fontanella (2000), Warkentin et al. (2000), Lancioni et al. (2000), Smaros and Holmstrom (2000), Keil et al. (1997), Chang (2002), Kraemer and Dedrick (2002), Morris and Morris (2002), Muffato and Payaro (2002), Simatupang et al. (2002), Van Tulder and Mol (2002), Davila et al. (2003), Skjott-Larsen et al. (2003), Ghiassi and Spera (2003), Jelassi and Leenen (2003), Karkkainen (2003), Karkkainen et al. (2003), Kumar and Zahn (2003), Swaminathan and Tayur (2003), Wagner et al. (2003), Steger-Jensen and Svensson (2004), Walton and Gupta (1999) and Teich et al. (2004)

of technology should also be considered for successful applications. Innovation also involves economic and political processes in the articulation of interests, the building of alliances, and struggles over outcomes. This includes the strategic interests of powerful corporate players and the struggles of these players for domination in the marketplace (Webster, 1995). Moreover, security-related issues after 9/11 have caused companies to reevaluate their international business activities in terms of identifying the right partners to safeguard the nation's security and its people. Also, governments around the world have changed their policies on international collaboration in all areas including commerce. In order to be successful in a global market, it is necessary to consider customer requirements through the forming of suitable strategic alliances and by pooling the core competencies of partnering firms. This again puts the focus on mass customization using BOSC.

Operations researchers do not seem to have given adequate attention to economic forces while formulating competitive strategies. Even during periods of economic recession some companies were able to perform well by implementing suitable business strategies and corresponding functional strategies. For example, economic depression and stock market

Table 3
Summary of references under the detailed classification scheme of the literature on BOSC

Major classification	Sub-classification	References
BOSC and organizational competitiveness	Economic factors	Sonntag (2000), Carayannis and Sagi (2001), Dedrick et al. (2001), Walters and Buchanan (2001) and Alessandri and Bettis (2003)
	Market forces	Porter (1980), Shapiro (1989), Papazoglou et al. (2000), Sonntag (2000), Jarratt and Fayed (2001), Childerhouse et al. (2002), Holweg and Miemczyk (2003a, 2003b) and Waller (2004)
	Competitive factors	Porter (1980), Shapiro (1989), Daugherty and Pittman (1995), Hult (2002), Kraemer and Dedrick (2002), Lei and Slocum (2002), Pearce (2002), Prastacos et al. (2002), Tse and Soufani (2002), Alessandri and Bettis (2003), Jelassi and Leenen (2003) and Carayannis and Sagi (2001)
Developing and implementing BOSC	Design and procurement	Lee (1996), Glasserman and Wang (1998), Bowersox et al. (1999), Jahnukainen and Lahti (1999), Cravens et al. (2000), Forza and Salvador (2002), Kraemer and Dedrick (2002), Thonemann and Bradley (2002), Van Tulder and Mol (2002), Skjott-Larsen et al. (2003), Davila et al. (2003), Hsu and Wang (2004), Muffato and Payaro (2004) and Teich et al. (2004)
	Partnership and virtual supply chain	Krause et al. (1998), Vrijhoef and Koskela (2000), Graham and Hardaker (2000), Holweg and Pil (2001), Weber (2002), Svensson and Barford (2002), Ghiassi and Spera (2003), Swaminathan and Tayur (2003), Biswas and Narahari (2004), Naylor et al. (1999) and Chung et al. (2004)
	Logistics	Holweg and Miemczyk (2002), Morris and Morris (2002), Chopra (2003), Holweg and Miemczyk (2003a, 2003b), Tyan et al. (2003) and Swaminathan and Tayur (2003)
	Implementation	Bhattacharya and Coleman (1994), Pawar and Driva (2000), Forza and Salvador (2002), Power and Sohal (2002), Svensson and Barford (2002), Erhun and Tayur (2003), Ghiassi and Spera (2003), Brunn and Mefford (2004), Muffato and Payaro (2004), Partanen and Haapasalo (2004) and Power and Simon (2004)
Operations of BOSC	Planning/forecasting	Banker and Khosla (1995), Chen et al. (2000), Hegedus and Hopp (2001), Geunes (2003), Iyer et al. (2003) and Biswas and Narahari (2004)
	Coordinating	Kolisch (2000), Song and Yao (2002), Wagner et al. (2003) and Biswas and Narahari (2004)
	Monitoring	Griffiths and Margetts (2000), Chen et al. (2003) and Biswas and Narahari (2004)
BOSC and information technology	Internet, e-commerce, and ERP technologies	Graham and Hardaker (2000), Fontanella (2000), Warkentin et al. (2000), Lancioni et al. (2000), Chang (2002), Kraemer and Dedrick (2002), Simatupang et al. (2002), Van Tulder and Mol (2002), Ghiassi and Spera (2003), Jelassi and Leenen (2003), Swaminathan and Tayur (2003), Wagner et al. (2003), Skjott-Larsen et al. (2003), Davila et al. (2003), Steger-Jensen and Svensson (2004), Steger-Jensen (2004), Muffato and Payaro (2004), Walton and Gupta (1999) and Teich et al. (2004)
	Radio frequency identification	Ollivier (1995), Smaros and Holmstrom (2000), Keil et al. (2001), Karkkainen (2003), Karkkainen et al. (2003) and Kumar and Zahn (2003)

crashes led many companies to revisit their business strategies and competitive objectives, including agility. These forced changes to their organizational supply chains. BOSC is an outcome of such an organizational change to meet changing market requirements. Walters and Buchanan (2001) discussed the relationship between a new economy, new opportunities, and new structures for both manufacturing and service organizations. This indicates that when developing a company's strategies, external factors should be given very close attention, including the issue of developing BOSC. Without the support of the environment, pursuing BOSC could prove to threaten the very survival of a company. A successful company must compete within a proactive industry that has adequate government support; several established consortia, a selective consumer base, and a strategy for innovation that is open to change and allows companies the organizational freedom to form collaborations (Carayannis and Sagi, 2001).

The issue of robustness of strategy over financial market cycles and how this should influence the policies of companies needs to be studied. In addition, the lessons that managers should integrate into their business models to obtain similar competitive advantages that are robust to drastically changing market conditions require further investigation. Managers should study whether the strategies of their firm really are different from those of their competitors in important ways, and examine the barriers that limit their ability to respond to strategic innovators. They also need to remember that any strategy should maintain a focus on costs under all economic conditions. For example, the bursting of the dot.com bubble and the subsequent stock market crash caused companies to seriously consider their business strategies and models and to develop new models of manufacturing in order to compete in the global market. As outsourcing has become a major strategy for organizational competitiveness, B2B e-commerce has gained ground and led companies to the implement BTO systems in an effort to stay competitive in a global market where flexibility and responsiveness are the major objectives of competitive performance (Alessandri and Bettis, 2003).

Economic factors such as inflation, general economic conditions, the stock market, interest rates, and currency exchange rates influence a nation's industrial policies; hence, companies have to revise their strategies based on such factors. BOSC is one of the strategies for leveraging global outsourcing to face stiff competition.

5.1.2. Market forces

Market forces include the nature of the market, market growth, globalization, customer demand, regulation, product/market innovation, technology and its spread, business risk, and the economy. The inherent profit potential of an industry is determined by five industry-level forces: barriers to entry, the threat of substitution, the bargaining power of buyers, the bargaining power of suppliers, and rivalry among incumbent firms (Porter, 1980). When making decisions regarding the nature of BOSC, the above factors must be taken into account. The characteristics of BOSC can be defined by product portfolio, the number of suppliers or partnering firms, knowledge management skills, information technology and automation, and so forth. These factors should be aligned with various current market forces.

The generic marketing strategy options of low cost, differentiation, and focus remain the dominant strategy-decision models (Porter, 1985). Technical advances, global competition, the realignment of organizational processes with the markets that they serve, new rules of corporate strategy, and outsourcing to access or to extend organizational capabilities are influencing the nature of the client/organizational interface and changing the nature of competition in today's market place. This is true in the case of BOSC, which needs to be integrated with the dominant characteristics of present-day markets (knowledge-driven and centered on customer services). Accordingly, partnership/supplier selection in BOSC needs to be decided.

In effect, the markets and production systems have to co-evolve. The main challenge for the partnering firms is how each should support the other's objectives over both the short and long-term with appropriate decisions. Take, for example, the issue of striking a balance between product variety and production costs. BOSC is the outcome of an effort to develop well-integrated marketing and production systems to meet the requirements of individual customers. The ways in which the current generation of production technologies structures the formation and growth of product markets should be examined. Also worth examining is why firms, driven to stay competitive, are adopting

manufacturing strategies that focus on reducing the time it takes to develop and manufacture new products (Sonntag, 2000). BOSC is an appropriate strategy for striking a balance between delivery time and product customization. It also performs well in many objectives of competitive performance, including cost and quality. This indicates that suitable models to optimize the level of customization and the lead time for the delivery of products need to be developed to facilitate the development of BOSC.

The strategic conflict approach emphasizes one of the above five industry-level forces, while giving a broader view of the firm's environment (Porter, 1980). Firms make moves that influence the behavior of rivals and therefore of the market environment, such as investing in new capacity or in advertising (Shapiro, 1989). For example, the timing of the investment in new capacity or advertising should be optimized so that a company can be assured that it has enough capacity to meet changing market requirements both in terms of variety and volume. Market forces influence the infrastructure of BOSC in terms of strategic alliances, partnerships, customer relationship management, information technology and systems, performance measures and metrics. Jarratt and Fayed (2001) described how marketing strategies are evolving in the context of this new competitive and organizational environment. Some of the ideas discussed in this paper can also be used to examine marketing forces and their impact on BOSC. A structured methodological framework for BOSC to specifically aid practitioners in developing a focused demand chain strategy, allowing companies to remain international players in a fast-changing business environment, would be helpful (Childerhouse et al., 2002). This involves determining the optimal values for various marketing instruments considering the production capacity and further to determine the optimal configuration of BOSC.

In their paper, Prastacos et al. (2002) listed the components of the new competitive landscape as those of flexibility and innovation. The enablers are internal capabilities, and information and communication technologies. The following are objectives that companies should consider pursuing:

- Change the company's strategy from one of duplicated mediocrity to one that is virtually world class.
- Change the company's structure from one of formal rigor to one of ad hoc support.
- Change the company's processes from sequenced steps to producing to systematic flows for value.
- Change HR polices from people as a workforce to people as a competitive force.

These factors clearly demonstrate the importance of BOSC in achieving speed and flexibility in responding to customer requirements.

5.1.3. Competitive factors

Competitive forces include customers, suppliers, rivals, new entrants, and substitutes. As noted earlier, Dell Computers has increased its market share in PCs considerably by using online sales. Companies such as Compaq and Gateway have also started developing BOSC to compete in customization, the timely delivery of products, and cost. Dell's success has influenced other companies such as Gateway, Compaq, and Hewlett-Packard to revise their operations paradigm and, hence, their corresponding BOSC operations. Global competition, advancements in technology, industry deregulation, and rising customer expectations are only a few factors that are placing unprecedented demands on business enterprises (Papazoglou et al., 2000). More research is required on the implications of factors external to the organization on the performance of BOSC in terms of costs, benefits, and customer service.

For example, by focusing on product innovation and consciously following the model of other standards leaders will help their companies become more competitive with BOSC. Following Microsoft, Cisco uses the Internet and IT to tie together virtual organizations (supplier firms), leveraging the capabilities of external partners to support rapid expansion while maintaining high levels of customer service and operational responsiveness. The following are the major factors of competitive success: innovation, new products, the creation of business ecology, the battle for talent and ideas, execution, cost, quality, speed, and the ability to attract customers (Kraemer and Dedrick, 2002). These factors are to be embedded in BOSC in various forms with the ultimate objective of meeting the requirements of individual customers on time and in a cost-effective manner.

The rising importance of knowledge work, the growth of substitute products and services, and the increasingly information-intensive nature of the value-adding activities of many industries are forcing companies to change their operations paradigm. The competitive factors that are forcing companies to go for BOSC are: a marked reduction in prices, customization, the collapse of product life cycles, widespread knowledge, the disappearance of traditional barriers to entry, changes in competitors, and a new customer base. The following are some strategies/tactics that companies could employ to stay competitive by developing an effective BOSC: fund new technologies, encourage new ideas, create new products, align with firms that have the same mission and objectives, encourage internal competition, and find new partners (Lei and Slocum, 2002). Traditional operations research models can also be applied to determine the optimal areas of investment for developing a BOSC. However, the difference in focus and configuration needs to be taken into account in the efforts at modeling and optimization.

BOSC should integrate the dimensions of entrepreneurship, innovation, and organizational learning to allow a company to be agile in responding to customer requirements. Hult (2002) examined a framework for sustainable competitive advantage as it pertains to global sourcing. He adopted a customer perspective and focused on entrepreneurship, innovativeness, and learning in an organization's long chain of interrelationships within global sourcing processes. The customer actually drives the BOSC and, therefore, these factors should be given due attention in designing a BOSC.

5.2. Developing and implementing BOSC

Very few articles appear in this area in the literature related to BOSC. Developing and implementing BOSC includes designing products and coming up with a procurement process, developing partnerships and a virtual supply chain, and managing logistics. This is an important area in which numerous medium to long-term decisions are made, and their impact on the performance of BOSC is significant. Issues of implementation in BOSC are not generally discussed at length and, therefore, deserve attention.

5.2.1. Design and procurement

The design of products and procurement of materials are the major activities in BOSC. In BOSC, the production system needs to be flexible and responsive enough to meet the requirements of individual customers. Reducing the lead time in products design, and efficiently procuring raw materials and components are important in the ability to respond to individual customer requirements as quickly as possible. The proliferation of products and uncertainties over demand can result in difficulties in material requirements planning (MRP), which lead to high inventories and poor customer service. A design concept and delays in differentiating products are advocated to reduce the impact of inaccurate forecasts and the shortening of order response times (Hsu and Wang, 2004) in a supply chain environment, in particular BOSC. Analytical or simulation models should be developed to optimize the variety of products and their impact on the other objectives of competitive performance. This will provide some new insights into the possible areas for development in BOSC.

BOSC relies on suppliers' promised deliveries without compromising on quality. Glasserman and Wang (1998) studied the trade-off between inventory levels and the delivery lead time offered to customers in achieving a target level of service. They addressed the question of how much a delivery lead time can be reduced, at a per unit increase in inventory, at a fixed fill rate. MTO supply chains consist of many successive business units, such as sales, purchasing, manufacturing, and assembly. Typically, the share of the costs of the purchased components of the product is 70–80%. Therefore, efficient purchasing is essential for MTO companies (Jahnukainen and Lahti, 1999). The role of the purchasing function is not explicitly studied in BOSC; therefore, this particular subject offers more avenues for research and application.

Its close relationships with suppliers and their support have allowed Dell to develop BOSC and to operate nearly no work-in-process inventory. In fact, Dell averages less than 1 day's inventory and supply of component parts. They ''pull'' parts from suppliers just as they are needed for production. Communication technologies such as fax or phone messages with replenishment requirements are forwarded to suppliers based on actual orders. BTO means that there is no finished inventory in the channel to manage

(Bowersox et al., 1999). This could be achieved by product modularity, risk-pooling, e-procurement, and strategic alliances.

One of the most difficult issues for operations managers is the proliferation of products. This is particularly true in mass customization and in a global market. Product proliferation makes the accurate forecasting of demand difficult, and consequently, leads to high investments in inventory and poor customer service. Different markets may have different requirements for a product, due to differences in taste, language, geographical environment, or government regulations. BOSC management should be the best alternative in this kind of environment (Lee, 1996). Some inventory models can be used to support the logistical dimensions of the design of products/processes.

For example, Dell focuses its sales and supply chain strategy largely on the flexibility that a product architecture provides (Maglitta, 1997). Modular product architectures allow for a greater variety of products while also significantly reducing the production of components and inventory holding costs through both risk pooling (Simchi-Levi et al., 2000) and demand pooling (Balakrishnan and Geunes, 2000). The benefits of risk-pooling appear in the form of reduced costs in the component safety stock through the use of components that are common to the bill-of-materials (BOM) of more than one end product in MTO environments. Demand pooling refers to the ability to aggregate demand across more than one end product to reduce unit production costs by using common or substitutable components. Thonemann and Bradley (2002) presented a model for analyzing the effect of product variety on supply-chain performance with a single manufacturer and multiple retailers. Addressing these issues will greatly benefit the design and development of an effective BOSC.

Offering a broad range of products to meet different consumer preferences without driving production costs to prohibitively high level presents a significant challenge to manufacturers. A key element to enabling efficient mass customization is a common product design platform that incorporates modular product architectures. Today's personal computer systems provide a good example of products that are differentiated from one another through features such as CPU speed, memory, and a variety of other features enabled by inserting an electronic circuit board or chip in a standard-sized slot (Geunes, 2003). BOSC requires the point of differentiation to be identified and the parts, components and modularity to be grouped to offer a range of products. This indicates the direction that further research in BOSC can take.

E-procurement and e-fulfillment facilitate the development of BOSC. The following are the advantages of e-procurement and e-fulfillment projects: (a) better management of the information and knowledge exchanged with suppliers and customers; (b) better control of supply operations; (c) fewer mistakes related to procurement; (d) better control of sales; (e) optimization of warehouse stock; (f) better control of market trends; and (g) an increase in the number of products supplied by the main suppliers (Muffato and Payaro, 2004). A global inter-organizational supply chain such as a BOSC requires seamless procurement to facilitate the timely exchange of information and, hence, the smooth flow of materials along the value chain.

5.2.2. *Development of partnerships and suppliers*

It is essential to develop partnerships and suppliers based on an OEM's core competencies in order to develop BOSC. For example, a virtual enterprise (VE) is based on developing a network of collaborative firms with the necessary core competencies to reach the market on time with the right products. Developing a network of firms requires a communication system to achieve a cooperative supported work. This could be achieved by utilizing various telecommunication technologies. Krause et al. (1998) offer empirical evidence on reactive and strategic processes of supplier development. The strategic development of suppliers enables companies to proactively consider all the productivity and quality problems along a value chain. The strategic approach seems to outperform the reactive approach in terms of developing suppliers to offer their best possible services to companies.

A company can utilize the capabilities of suppliers by developing its sourcing structure, clarifying its sourcing policies, and increasing integration and cooperation in its operations. It has been suggested that there is a need to separate operative purchasing and supplier management if BTO is to be supported effectively. Van Tulder and Mol (2002) looked at how electronic auctions can be affected by various trade-

offs in sourcing strategy and showed that firms still mostly have to deal with the same issues/problems even when auctions are used, as regional sourcing strategies rather than global ones are the norm for most European firms. To be effective, electronic auctions should be used as part of a wider strategy, and appropriate selection criteria should be set up in advance. Graham and Hardaker (2000) highlighted the role of the Internet in building commercially viable supply chains in order to meet the challenges of virtual enterprises. Without the application of the Internet, a company is unlikely to achieve a BOSC. This technology connects suppliers and customers along a global supply chain. The idea of virtual enterprises is intriguing, but poses a challenge from the practical perspective of the establishment of such an enterprise. This area needs further investigation to clarify any misunderstandings regarding the role of virtual enterprises in BOSC.

The close relationships Dell has with its suppliers and their support have allowed Dell to operate nearly no work-in-process inventory. In BOSC, parts from suppliers are pulled just as they are needed for production (Bowersox et al., 1999). Biswas and Narahari (2004) developed a decision-support system for supply chains through object modeling, which enables strategic, tactical, and operational decisions to be made in supply chains. This paper is certainly a positive step towards developing an integrated decision-support system (DSS) for SCM. However, the application of such a DSS that incorporates all levels of decisions will cause some difficulties in using the system with confidence in BOSC, considering the strategic and dynamic nature of the enterprise environment.

A virtual organization is a part of a BOSC. For example, an OEM performs only assembly operations. The remaining operations will be carried out by partnering firms or suppliers. Cisco Systems has used the Internet, e-commerce, and information systems to create a virtual organization, outsourcing many operational and customer-service functions and focusing its own resources on its core product innovation strategy. Cisco uses the Internet and e-commerce to tie its own personnel together with its customers, suppliers, and business partners in a virtual organization, and has been pointed to as a quintessential network-era company (Kraemer and Dedrick, 2002).

The criteria used for forming partnerships and developing suppliers for BOSC should differ from those of TSCM. For example, suppliers should support the scheduling of pull type production, be flexible in the variety of components they offer, and in volume and delivery requirements. The relationship should be collaborative and responsive.

5.2.3. *Logistics*

Logistics involves transportation, consolidation, and warehousing. Delivering products on time requires an effective and efficient logistics chain. Daugherty and Pittman (1995) explored the use of time-based strategies throughout the supply chain, from manufacturing to point-of-sale. They placed an emphasis on supporting distribution operations. Distribution services are especially critical to the successful implementation of time-based strategies, in particular BOSC.

Chen et al. (2001) addressed a basic two-echelon distribution system, in which the sales volumes of retailers are endogenously determined on the basis of known demand functions. They studied a distribution channel where a supplier distributes a single product to retailers, who in turn sell the product to consumers. This type of optimization model can be used to determine the optimal level of distribution in BOSC in order to deliver products as quickly as possible.

Companies such as Dell and Compaq extensively utilize third-party logistics (3PL) and fourth party logistics (4PL) service providers, which include DHL, FedEx, and UPS. 3PL is the management of logistic services beyond transportation. This might include storage, transshipment and value-added services as well as the use of subcontractors. 4PL is the integration of all companies involved along the supply chain. 4PL is the planning, steering, and controlling of all logistic procedures (including flows of information, material, and capital) by one service provider with long-term strategic objectives. UPS World Wide Logistics employed a 4PL business model. It has achieved full supply chain integration and the strategic application of the available information to the benefit of the company's clients. This model initially applies the integration of information in logistics and transport operations. Also included in the model are supply practices over the Web, in which several players team up flexibly to align to the end consumer (Van Hoek and

Chong, 2001). This model can be used to utilize the advantages of integrated logistics and transport operations to speed up the delivery of products in BOSC.

Holweg and Miemczyk (2003a) developed a framework that allows vehicles to be built to the order of customers with minimal lead times. They assessed whether current logistics systems are capable of supporting such a BTO approach, and established key constraints in the current logistics of vehicle distribution, as well as the cost and environmental impact of more responsive logistics. Compaq and Dell Computers are possibly the most frequently cited examples of companies in an integrated global supply chain management. However, the role and operations of participating global 3PL providers have received less attention in the literature. In the volatile BTO and CTO markets, the integrated 3PL has to adjust its traditional freight consolidation strategies to simultaneously meet service commitments and minimize distribution costs (Tyan et al., 2003).

Chopra (2003) described a framework for designing the distribution network in a supply chain. Dell distributes its PCs directly to end consumers, while companies like Hewlett-Packard distribute through resellers (Margretta, 1998). Dell customers wait several days to get a PC while customers can walk away with an HP from a reseller. Since Dell operates on a BTO supply chain while HP operates a TSCM, Dell requires more time to fill an order. The process includes configuring the product, obtaining materials from global suppliers, assembling and then delivering the product. The logistics involved in co-coordinating the material flow along the global BOSC is complicated and therefore, leads to several optimization variables. These are the reasons why Dell customers have to wait several days for their order to be delivered. Apple Computers has opened retail stores, which have been proved to be successful (Wong, 2001). This indicates how important the downstream logistics of a supply chain are in developing a BOSC. In this endeavor, one of the most suitable alternatives is 3PL.

BTO will have a strong impact on the entire automotive supply chain and logistics operations. The integration of inbound, outbound, and export shipping planning and operations could yield large benefits. Strategic imperatives derived from build-to-order supports the integration of the whole logistics supply chain (Holweg and Miemczyk, 2003b). Numerous articles are available in the literature on logistics, but a very few discuss the role of logistics (in particular 3PL) in BOSC. Further research on this subject is warranted.

5.2.4. Implementation

Implementation involves putting the plan for BOSC into action. BOSC needs to be constructed based on the design and procurement of products and plans to establish partnerships, a virtual supply chain, and logistics. This requires the setting up of an implementation team, a time scale for the project, and evaluating the performance of the process of implementing BOSC.

Barriers to the implementation of e-commerce in managing the supply chain need to be identified and addressed. Most of the issues discussed here will also be applicable to BOSC. However, there are not many research articles on the implementation of BOSC to help other companies learn about the best practices from other successful companies. Power and Sohal (2002) discussed issues of implementation from the perspectives of the complexity of the supplier network, the effective life cycle of products, the nature of the components used, cultural issues, and the support of top management. A seven-step implementation framework can be employed for electronic trading in a supply chain: (a) develop a strategy, (b) make an assessment, (c) create the culture, (d) make improvements in priorities, (e) plan the changes, (f) implement the improved situation, and (g) support the implementation (Pawar and Driva, 2000). This framework could also be utilized for BOSC, as these steps are generic for any process of change. Partanen and Haapasalo (2004) reviewed the elements of mass customization for rapid production systems. They discussed theoretical models for the implementation of systems of mass production. These models could be modified to suit the perspectives of BOSC. Various project-oriented frameworks can also be utilized to effectively implement BOSC.

Erhun and Tayur (2003) described an enterprise-wide tool for tactical planning at a grocery retailer. They claimed to observe a reduction in on-hand inventories, an increase in service levels, and substantial improvements in logistics decisions. The

total landed cost was substantially lower – with an improvement of 20.85 in operating costs, or 11.6% of net profits – while superior fulfillment was provided to the stores. The tool optimizes across logistics, purchasing, and warehouse management, while considering the necessary economics of joint replenishment and accounting for a wide variety of complexities, such as discounts on total order quantity, intermittent demand, multiple distribution centers, vendor deals and forward buys, and promotions. This enterprise-wide tool can be used for managing BOSC. Significant relationships have been recorded among company size, industry sector, and the extent of implementation (Power and Simon, 2004). This should be recognized when we attempt to implement BOSC. Brunn and Mefford (2004) discussed the implications of the World Wide Web (WWW) on the implementation of lean production by facilitating communication among partners in a supply chain with shared and transparent information. However, the WWW has its own limitations such as in security and flexibility. Nevertheless, it has become an essential technology for developing interfaces between customers and suppliers along BOSC.

5.3. Operations of BOSC

Once a BOSC system has been developed, the next step is to plan for operations based on forecasts of the demand for different products over a year. Based on forecasting, a system of master production scheduling (MPS) can be developed for the end products, and then an MRP with the help of a bill of materials (BOM). Various functional areas should then be coordinated to obtain the required resources and activities. Attention should be paid to ensure that all of the activities are integrated so that the product can be delivered to customers on time. While production is in progress, if something goes against the planned production schedule, alternative courses of action should be taken in order to bring the schedule under control.

5.3.1. Planning/forecasting

In recent years, companies have started recognizing the trade-off between product variety and supply-chain performance. Some firms have sought to optimize the number of products they offer, trading off the benefits of a larger product portfolio for better supply-chain performance. They have planned for various resources including materials and people to build products based on orders; and for procurement activities with suppliers and other service providers. Although the system is BTO, component clustering is still required and it is still necessary to determine the point of differentiation. The volume and timing of such resources should be determined based on the various trade-offs between performance objectives, with the sole aim of reaching customers with the right products as soon as possible. The sharing of information is important for more feasible and practical planning and forecasting. Important issues with reference to planning and forecasting with BOSC are discussed in this section.

Companies need to learn how to integrate their own internal functions while coordinating them with those of their inbound suppliers. Communications on long-term forecasts, current demand, and perceived changes should be made available to supply chain partners. Information on customer demand is increasingly being made available to a company's first-tier suppliers (Griffiths and Margetts, 2000). This highlights the importance of providing suppliers with accurate requirements on components so that they can be more responsive and competitive in terms of providing high-quality and cost-effective products for BOSC.

MTO producers of such goods as ships, airplanes, and large-scale machine tools face the production planning problem in which multiple customer-specific orders have to be manufactured subject to strict deadlines, while at the same time there are long lead times resulting from order-specific assembly and special parts that have to be fabricated in-house or procured outside (Kolisch, 2000). A company can outsource assembly and special parts to avail itself of a more flexible and responsive way of meeting changing customer requirements. Chen et al. (2000) quantified the bullwhip effect (where the impact of demand variability amplifies as one moves up a supply chain) for a simple supply chain consisting of a single retailer and a single manufacturer. They argued that the bullwhip effect can be reduced, but cannot be completely eliminated. Appreciating the bullwhip effect based on the accuracy of forecasting, it is essential to accurately estimate the volume and timing of the components needed to build products based on customer orders along the supply chain.

Hegedus and Hopp (2001) proposed a new model for quoting due dates in an MTO environment where customers request due dates. The model incorporates inventory costs, fill rate issues, and service-level issues. In particular, they considered order delay costs that measure the positive difference between the due date requested by the customer and the due date committed by the supplier. Demand postponement as a strategy to handle potential surges in demand could be an effective tactic in BOSC (Iyer et al., 2003). With the postponement of demand, a fraction of the demands from the regular period are postponed and satisfied during a postponement period. They have formulated and solved two-stage capacity planning problems under the postponement of demand.

BOSC planning and execution involve managing partnering firms that are dispersed all over the globe. It is to be noted that the objective of partnering firms in BOSC should be incorporated in the planning. Although BOSC is based on customer orders, partnering firms or suppliers need to know the forecast of the demand for parts and components. A decision support system would enable strategic, tactical, and operational decision-making in supply chains that will be helpful in BOSC. This can include a modeling infrastructure comprised of a library of carefully designed generic objects for modeling elements of BOSC and dynamic interactions among these elements (Biswas and Narahari, 2004).

Although BOSC is a MTO system, there is a need for the aggregate forecasting of demand for the final products for 1–2 years. This information could be transmitted to suppliers to allow them to make available the required components and services at the right volume and at the right time.

5.3.2. Coordinating

A BOSC system has different requirements from those of standard mainstream production operations. Additional requirements for a BTO system should include ending the day with no work-in-process, maintaining zero inventories on finished goods, and building products to order only. Companies need to learn how to integrate their own internal functions and to coordinate them with those of their inbound suppliers. Communications regarding long-term forecasts, current demand, and perceived changes should be made available to partners in the supply chain. Information on customer demand should be made available to a company's first-tier suppliers (Griffiths and Margetts, 2000).

Song and Yao (2002) studied a single-product assembly system in which the final product is assembled to order, whereas the components (sub-assemblies) are built to stock. They show that it is desirable to keep higher base-stock levels for components with longer mean lead times (and lower unit costs). This model, which uses an M/G/α queue with a common arrival stream, can be used to coordinate OEM and suppliers in BOSC.

Once the planning and forecasting for both the inputs and outputs are done along BOSC, the next stage is to obtain all of the necessary resources including people, materials, and other support services so that goods can be produced according to plans and forecasts. MPS and MRP are part of this activity. In BOSC, this activity requires ensuring that the assembly unit and all suppliers know their delivery commitments in advance based on MPS and MRP. Changes will be made based on need and within the limits so that the overall production plan is not affected.

Definitions and specifications can be given to a discrete BTO supply chain on how task analysis environment modeling and simulation (TAEMS) agents, equipped with new mechanisms for coordination, can automate and manage the supply chain. The agents increase the level of flexibility in the chain and enable members of the supply chain to be more responsive by negotiating between producers and consumers, and reasoning about the availability of manufacturing facilities, raw material requirements, and shipping time requirements. Planning/scheduling and research on coordination enables the agents to perform this level of automation on-line, responding to changes as they happen in the environment, rather than replying to pre-computed solutions or reasoning via characteristics of abstract flow (Wagner et al., 2003). Biswas and Narahari (2004) developed a decision support system, which will enable strategic, tactical, and operational decision-making in BOSC.

The BOSC system requires new systems to actually book a production lot in sequence for a particular customer order. As the order is generated, the schedule for suppliers is generated, and the sequence is built on a car-by-car basis, using algorithms as they are used now, to optimize the sequence of production.

However, the line balancing optimization that is taken for granted now will also have to change to allow for volatility in demand from the market place (Waller, 2004).

Coordination in BOSC is complex and primarily involves managing suppliers and other resources as well as the demand chain or customer relationships. Since customer orders trigger the processes of production, there is a need to integrate the requirement for coordination throughout the supply chain to ensure that products are manufactured and delivered on time using the shared and transparent information system wherein stakeholders in the order can see the status of the goods.

5.3.3. Monitoring

After the value-adding activities have started and if things do not progress as planned, there is a need to make some adjustments so that the production process can move according to the planned schedule according to MPS and MRP. This requires short-term scheduling changes in BOSC.

Chen et al. (2003) presented an integrated information system for use in the shop floor controlling system (SFCS) for kitting parts, producing goods, and packing and distributing finished goods, to enhance the performance of the BTO/CTO production system. Several information technologies and devices, such as the barcode system, the electronic pick-to-light picking system, electronic Kanban (eKanban), and others are adopted to support the relevant logistics. A responsive production controller is required to make appropriate decisions and to quickly meet the requirements of the BTO/CTO production system.

A variety of scheduling, batching, and delivery problems that arise in an arborescent supply chain should be considered in BOSC, where a supplier makes deliveries to several manufacturers, who also make deliveries to customers (Hall and Potts, 2003). They demonstrate that cooperation between a supplier and a manufacturer may reduce the total cost of the system by at least 20 or 25%, or by up to 100%, depending upon the scheduling objective. For example, a decision workbench can potentially include powerful algorithmic and simulation-based solution methods for BOSC decision-making (Biswas and Narahari, 2004). A suitable DSS should be developed considering the type of decisions one has to make in BOSC. Decisions such as optimal partnership selection, which is based on their core competencies and past competitive performance; optimal point of delayed product differentiation; the selection of optimal distribution channels incorporating consolidation of deliveries, and so forth should be considered when developing a DSS for BOSC. Suitable ERP modules can be used for making decisions in BOSC based on the nature of the decisions to be made. These could be in sales, purchasing, design, logistics, production, etc.

Determining optimal scheduling, batching, and distribution policies should be considered with adequate seriousness in BOSC as they influence customer service and, in turn, the overall competitiveness of BOSC organizations. For example, the delivery of parts and components from suppliers to the assembly plant requires decisions such as the timing and volume of the orders. The same decisions should be applicable for the distribution side of BOSC.

5.4. BOSC and information technology

Internet technology is essential to managing BOSC activities as it can offer information about what kind of product is demanded, what is available in the warehouse, what is involved in the manufacturing process, and what is entering and exiting the physical facilities and customer sites (Lancioni et al., 2000). For example, via extranets, ERP systems such as SAP, Peoplesoft, BAAN, Oracle, and JD Edwards connect not only different functions within a firm but also functions among the firm's supply chain partners (i.e., suppliers, distributors, and third-party logistics providers). This enables the partners to share information such as order status, product schedules, and sales records, to integrate major supply chain processes and to plan production, logistics, and marketing promotions (Overby and Min, 2001). The application of IT in BOSC can be seen in Table 4.

The application of IT in BOSC can be described in Table 4 in five major areas. The first one is ''Informational''—online information about products and customers, FAQ, contact person, return policy, etc. The second area is ''Transactional,'' which covers online order submissions, order tracking, secured online payments, and technical assistance. Basically,

Table 4
Application of information technology and BOSC

Application area in BOSC	Detailed activities in BOSC
Informational	Online information about custom and standard products, a comprehensive, frequently asked questions section, contact person, return policy, etc.
Transactional	Online order submission, order modification, order notification, order tracking, security of online payment, and technical assistance
Partner orientation	Customer profiles, products, prices, locations, quantity, and demand patterns
Resource planning	Forecasting, shipping schedules, inventory, capacity, location, lead times, and products
Contract status	Price, automatic ordering, order status tracking, invoicing, auction, incentive score-board and electronic payment

Source: Simatupang et al. (2002).

these two areas facilitate customer relationship management in BOSC. The third area, ''Partner orientation'' includes supplier development activities as well as demand management. These activities should include customer profiles, products, prices, locations, quantity, and demand patterns. The fourth area of application is ''Resource planning,'' which involves forecasting, shipping schedules, inventory, capacity location, lead times, and products. These cover the operations of BOSC. The fifth area is ''Contract status,'' which covers price, automatic ordering, order status tracking, invoicing, auction, incentive score-board, and electronic payments. This area of IT deals with the control of the supplier chain in BOSC.

The organizational design of BOSC is rather flexible, as it takes its structure according to the nature of the business and strategic alliances, including the characteristics of the market and business processes. For the organizational forms of complex systems, Eisenhardt and Brown (1998) argued that (a) organizational forms that have neither too little nor too much structure; and (b) organizations that have an adaptive culture with semi-structures use real-time communications. However, the standardization of business processes and IT systems facilitates effective and protected access to information in a supply chain.

5.4.1. Internet, e-commerce, and ERP technologies

Point-of-sale information programs have been a major influence in altering the thinking among logistics managers that the exchange of data in a supply chain can be beneficial to all of the parties involved. The use of the Internet provides numerous cost-saving opportunities for supply chains. Numerous companies have experienced the benefits of the Internet (Lancioni et al., 2000). For example, the Internet reduces the lead time for order processing and transportation; and effective inventory management, and pickups and deliveries of shipments can be more accurately monitored. Also, customers receive 24 h service, and vendor relations have improved with the Internet in SCM.

Kehoe and Boughton (2001) discussed the following key elements of a study on the role of the Internet within a manufacturing supply chain: (a) a detailed examination of the current use and operation of the Internet within manufacturing supply chains, and establishing the industry practice in this area, (b) building a dynamic model of the web-based supply chain in each of the collaborative industrial sectors, (c) the HTML prototype for the supply-Web model, and (d) sector-based models and prototypes. Considering the application of IT in BOSC, the shared information system plays a major role in establishing trust and a cooperative supported work along BOSC (Fontanella, 2000).

SAP R/3 has been widely implemented to create value-oriented supply chains that enable a high level of integration, improve communication within internal and external business networks, and enhance the decision-making process. Al-Mashari and Zairi (2000) highlighted the importance of IT infrastructure in the successful implementation of SAP/R3 for reengineering supply chains. The issues they discussed are equally applicable to BOSC. The framework they presented can also be used to implement ERP for

BOSC. Benjamin and Wigand (1995) explained the integration of electronic markets and virtual value chains on the information superhighway. Their explanation could perhaps be used in integrating the activities of BOSC with suitable Internet-driven enterprise information systems.

Becoming involved in trading over the Internet is not without problems for the supplier. Interoperability; the building of trust, confidence and security; and the need for a regulatory and legal framework are all issues of concern. Murillo (2001) discussed the implications of e-commerce on supply chain management and its effectiveness. BTO not only requires just-in-time (JIT), but also the most advanced computerized versions of ERP. By facilitating real-time communications between suppliers, production functions, marketing functions, and the final customer, e-commerce has become an essential component of BTO (Doherty, 2000). Considering these, JIT can be said to be an integral part of the operational strategies of BOSC incorporating the application of Internet technologies. There is scope for further research on the application of JIT in BOSC.

BOSC problems can be instances of a class of distributed optimization problems that TAEMS and other intelligent agents were made to address. Wagner et al. (2003) defined a discrete distributed dynamic supply chain management problem and specified how TAEMS agents, equipped with new mechanisms for coordination, automate and manage BOSC. The agents increase the level of flexibility in the chain and enable members of BOSC to be more responsive through producer/consumer negotiations and reasoning about the availability of manufacturing facilities, raw material requirements, and shipping requirements.

The infusion of information technology into business operations is drastically changing the way businesses operate. In addition, the universal availability of the Internet is accelerating the mass customization of products—from PCs to automobiles. Managing relationships in BOSC, therefore, necessitates the adoption of a new production paradigm characterized by a centralized strategy, but decentralized operations; a synchronized supply chain management system; collaborative partnerships among selected suppliers; a new, interoperable, and open information system infrastructure; brokers; and an intelligent, mobile, agent-based trading system.

The industrial revolution that took place in the past decade can be traced to technological innovations such as the Internet and the Web. Subsequently, ERP systems have played a major role in developing BOSC. Also, developments in hardware and telecommunication technologies have occurred to meet the rise in demand from companies. The ERP systems represent an optimum technology infrastructure that, when integrated properly with a process-oriented business design, can effectively support supply chain management systems including BOSC (Mullen, 1997).

Boubekri (2001) described how ERP is increasingly being used as a technology enabler for SCM and for problems associated with its implementation. Cisco Systems has used the Internet, e-commerce, and information systems as part of its broad strategy to establish a dominant technology standard in the Internet era. It has used these technologies to support its strategy in several ways: (a) to create a business ecology to reinforce its control of key technology standards in the networking market, (b) to create a virtual organization, outsourcing many operational and customer service functions and focusing on its own resources on its core product innovation strategy; and (c) to showcase its own use of the Internet as a marketing tool. The Internet and e-commerce are used to tie together Cisco's own personnel with those of its customers, suppliers, and business partners in a virtual organization, winning the company the reputation of being the quintessential network-era company (Kraemer and Dedrick, 2002). These imply that ERP is an indispensable tool for developing and successfully managing BOSC.

Ghiassi and Spera (2003) described a software system that satisfies these properties and one that can support the business operations of a massively customized production system and its supporting supply chain partners. The mass customization of products implies the existence of a production infrastructure and process that can quickly change to produce customized products. This type of production infrastructure will be component-based and may involve many business partners, such as suppliers and other companies that affect the delivery of products to customers. BOSC requires a significantly greater degree of synchronization of the entire supply chain, including the entire inventory system.

For a group of companies and products, survival requires an integrated BOSC: one that can provide information to all members of the chain in real-time, while still producing customized products at a minimal cost to consumers. Warkentin et al. (2000) discussed the implications of mass customization in enhancing supply chain relationships in B2C e-commerce markets. For example, BOSC requires a stronger and closer relationship with suppliers to ensure that all component parts are made available at the right time and at the right place as required by the assembly plan. This necessitates the integration of suppliers with the value chain using a suitable e-commerce system so that there will be a smooth information as well as material flows.

Mass customization production is a challenge to existing production management systems. The opportunity to ensure the efficient utilization of the production system is reduced due to the BTO approach, which is most often associated with a strategy of customization. Existing software provides little support because they are mostly based on mass production approaches. BTO, on the other hand, has not been subject to the same attention as mass production and, as the problems involved are slightly different, the techniques of traditional industrial production can only be applied to a limited extent (Steger-Jensen and Svensson, 2004). For example, issues such as the integration of the activities of global suppliers, logistics service providers, and customer relationship management pose a tremendous challenge for researchers of IT/IS in developing a suitable ERP system for BOSC incorporating B2B e-commerce.

E-commerce plays a major role in integrating the value chain activities in BOSC. For example, B2B e-commerce can be used for bringing all of the partnering firms to the same platform, and B2C can be used in customer relationship management by offering a suitable web-based platform for placing orders and following up on them. For developing partners and suppliers, OEM can adopt e-auctions and exchanges in BOSC. Teich et al. (2004) reviewed the multiple issues involved in e-auctions and discussed their design features and performance criteria. They primarily considered B2B transactions in a reverse auction, that is, in a procurement setting. Davila et al. (2003) and Skjott-Larsen et al. (2003) discussed the relationship between Internet-driven electronic marketplaces and SCM from a procurement portfolio perspective, and the adoption and use of e-procurement technology models. These models and frameworks can be used for procurement in BOSC. However, the criteria used to decide on procurement will differ compared to that of TSCM.

5.4.2. Radio frequency identification

Radio frequency identification (RFID) is an emerging technology that provides major improvements to the efficiency and accuracy of materials handling systems along BOSC. Modern electronics has enabled all of the complexities of a radio system to be integrated on to a single chip. This technology enables items in transit through production systems, warehouses, and distribution systems to be individually monitored and tracked. Newer techniques even allow information about a product to be changed during the process (Ollivier, 1995). Open and shared information system facilitates trust between the buyer and seller, as well as the timely availability of products and support services in BOSC.

Considering the global and dynamic nature of BOSC, wireless technologies play a major role in developing a suitable communication system that is flexible and effective. Kumar and Zahn (2003) discussed the application of mobile communications in business operations. For example, the personal digital assistant (PDA) and the wireless database access server (WDBAS) have a wide variety of applications in business operations. PDAs support a wide variety of enterprise-level applications in fields ranging from industrial manufacturing to the airline industry to healthcare. Business and personal productivity applications range from document readers to street maps and vacation planners. Karkkainen (2003) discussed the potential of utilizing RFID technology to increase efficiency in the supply chain of products with a short shelf life. This paper concluded that when RFID is applied with recyclable transport containers, RFID investments can provide quick amortization of capital while offering a range of operational benefits that are important in BOSC.

Smaros and Holmstrom (2000) analyzed the opportunities offered by bar code and RFID technology to develop a new type of service related to e-groceries, namely a vendor-managed inventory (VMI). The idea

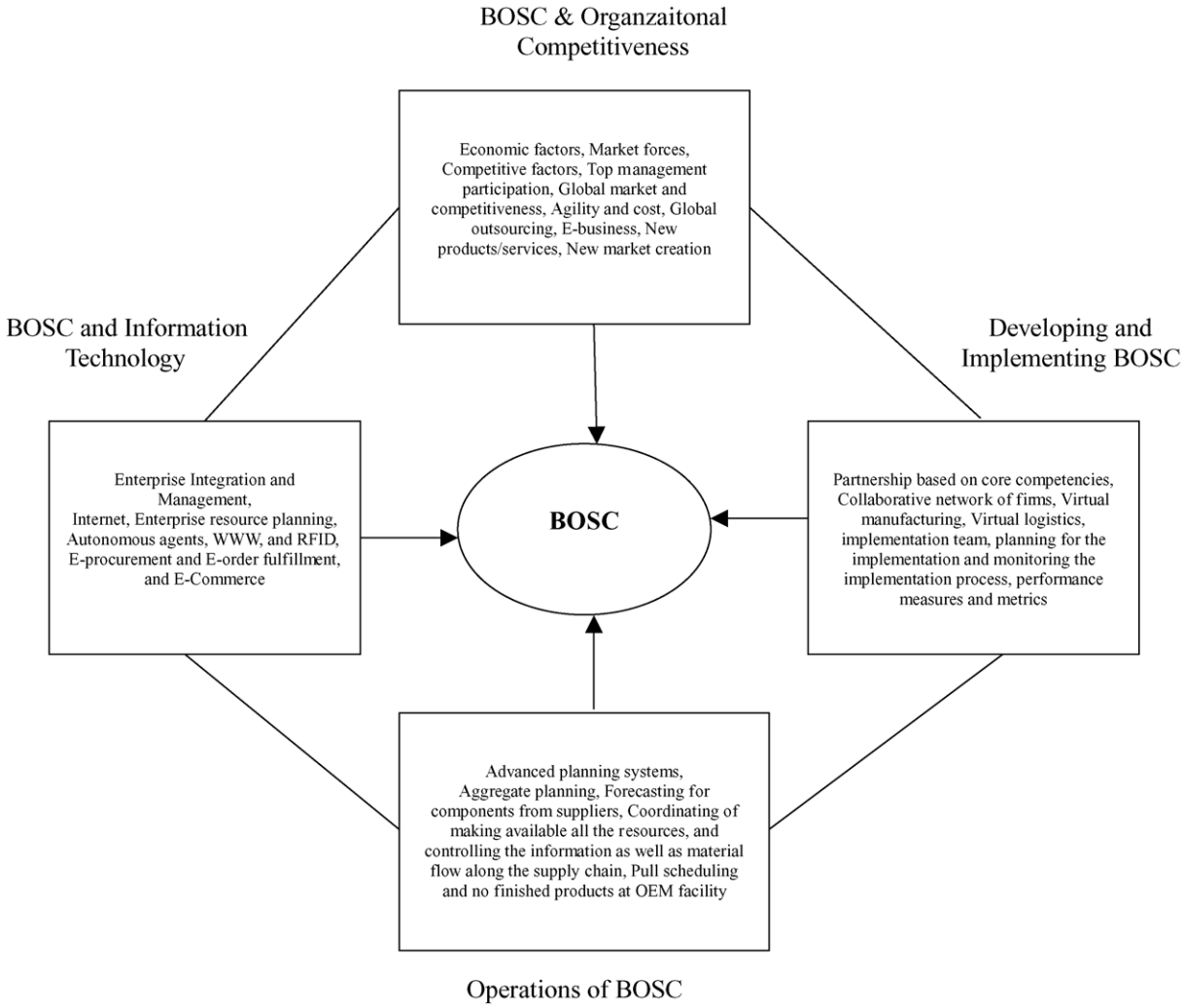

Fig. 1. A framework for the development of BOSC.

of VMI can be applied to a BOSC environment, where the inventory at partnering firms should be managed by the buyer. This will help the OEM to make available the required materials within a short span of time. This explains the importance of RFID in BOSC. A number of key operational issues are addressed, i.e. the capturing of data, the robustness of solutions, and the potential for cost savings in the supply chain. Karkkainen et al. (2003) investigated how the logistical challenges of international projects can be solved by utilizing advanced web technologies and identifying products. They presented a control system being built at their school that is based on distributed programming, and wireless identification technologies. The aim of the system is to change the controlling mechanisms of project deliveries by delivery chains controlled from the inside of the material flow itself. RFID will be an effective technology for tracking the materials easily in BOSC.

6. A framework for developing BOSC and the managerial implications

In this section, a framework has been presented for developing BOSC. This framework is based on a review of the literature on BOSC (see Fig. 1).

Reviewing the literature on BOSC helped to identify the major strategies, enabling technologies, and critical success factors for developing BOSC. This framework is based on the following the logical development of BOSC:

(i) The literature available (selected) on BOSC has been classified based on the nature of major decision-making areas and enabling strategies and technologies with the objective of developing and managing an effective BOSC.
(ii) The sub-classification of the literature is aimed at assisting both researchers and practitioners in identifying the potential areas of development and critical success factors for the successful development and operation of BOSC.

In its process of realization, the concept is somewhat similar to one-of-a-kind production (OKP) in heavy industry, but without the high manufacturing costs and unstable quality. The friction results in the following symptoms of BTO: order-processing is time-consuming and costly, revisions of specifications are multiple, delivery dates are often not met, last-minute changes take up an increasing portion of resources, production plans are inaccurate and are often over-ruled and, as turnover grows, profits decrease. Christopher (2000) has argued that agility is an important factor in supply chains. In BOSC, companies need to be market sensitive, and to leverage information technology, hybrid strategies, and postponement tactics.

The major issues that need to be addressed when developing BOSC are discussed in this section using criteria used to classify and review the literature, including: (a) BOSC and organizational competitiveness, (b) developing and implementing BOSC, (c) the operations of BOSC, and (d) BOSC technology. The details are presented below.

6.1. BOSC and organizational competitiveness

The strategic planning of BOSC is important, considering the factors that are internal and external to business organizations. For example, external factors such as economic, political, market, and competitive factors have significant implications on companies that are developing BOSC. Corporate and business strategies should be based on both of the above factors. The environment should be conducive for the strategy of BOSC. While formulating BOSC, strategies such as the types of products, location of the OEM firm, budget for developing BOSC, and competitive priorities should be decided upon, taking into account economic, market, and competitive factors.

Market factors such as the nature of the market (global and mass customization), product innovation, technological development, business risk, barriers to market, and so forth should be considered while determining the choice of BOSC. Competitive factors including customers, suppliers, rivals, new entrants and substitutes should be considered in developing BOSC. Top management is responsible for formulating upper-level strategies such as those mentioned above.

Managers who are in charge of developing BOSC should look more closely into the environmental factors and determine those that pose a risk to the development of BOSC. Again, it is not just the economy and political stability of one country that should be taken into account while developing corporate and business strategies incorporating BOSC. Since BOSC involves global supply management, this necessitates considering all of the related factors among participating countries both from the supply and customer sides. Developing a decision-support system would help managers make decisions on developing business strategies for BOSC.

6.2. Developing and implementing BOSC

Developing BOSC starts with the design of products and corresponding procurement systems. Once the design of a product is available, the question of modularity should be addressed. Thereafter, partnerships and suppliers should be developed. The process involves making decisions about at which stage along the supply chain the differentiation of products should occur, and about the integration of suppliers and customers with an enterprise resource planning system. Implementation requires project organization and the monitoring of the progress of the implementation of BOSC.

Managers responsible for developing and implementing BOSC should first examine the design of products and then look into procurement. The reasons

for this are that product design involves customization and, therefore, is a challenging area in the development and implementation of BOSC. Two important issues need to be examined: (i) commonality or clusters of components and (ii) modularity (sub-assemblies) for determining the point at which products are differentiated along BOSC. Managers need to develop a framework for developing suppliers and partners based on the components and other support services, as logistics requires reaching customers with the right products as soon as possible and in a cost-effective manner. Suitable performance measures and metrics should be developed to evaluate the suppliers and their products and services based on the need for BOSC. International project management training is essential for managers to implement BOSC. Logistics, in particular 3PL, is crucial for the timely delivery of products to global customers. This is applicable to incoming goods as well.

6.3. Operations of BOSC

The operations of BOSC require making decisions such as planning and forecasting, and coordinating and monitoring. The type of planning activity in BOSC involves determining the demand for components, and the timing and volume of orders to suppliers. Since BOSC is a ''pull'' system or a make-to-order system, the materials are pulled through the system based on customer orders. The question of buffers and inventories arises at the partnering firms in particular, for components as well as for raw materials. This has to be dealt with by advanced planning. Obtaining the necessary resources will be the next step in operations management in BOSC. These include raw materials, components, and other support services. Once the production process has started, it has to be monitored in real-time mode with the help of a web-based information system.

Although most operations research models and traditional practices of operations management can be applied to BOSC, different skills and orientations are required of operations managers. For example, operations managers in BOSC should be skilled at using and making decisions with ERP systems. They should also be multi-lingual in order to effectively communicate with global partners or suppliers. The job of an operations manager becomes more one of coordination in building products and procuring components. They are also responsible for scheduling the building of products, quality control, and inventory management. Operations managers should be knowledgeable in the pull type of production system, which includes Kanban, dynamic process quality control, and so forth. Managers should develop performance measures and metrics to measure the performance in areas such as planning and forecasting (for example, bullwhip effects), coordinating, and monitoring so that the timely delivery of quality products is ensured.

6.4. BOSC and information technology

Information technologies such as EDI, the Internet, the WWW, ERP, and RFID facilitate the integration of customers and suppliers or partnering firms along supply networks. Since suppliers or partnering firms are geographically dispersed, an effective communication system that is a real-time system is necessary. BOSC requires a system that can keep track of all orders and is well connected with supplier firms. Since most orders will be received online, high-speed Internet connectivity is required to allow customers to check products and place orders with complete confidence.

Information managers are responsible for identifying a suitable ERP system, including developing an e-commerce enabled customer-order system to facilitate the exchange of customer requirements in real-time and also to communicate with suppliers on components and other support services such as logistics. Information system managers should work with other company managers to select a suitable ERP system and/or e-commerce system based on their company's business model, which includes the integration of the OEM's system with those of partnering firms along the BOSC. The integration of the link between customers and suppliers is essential for BOSC. This can be achieved by suitably aligning the information system with the business model of BOSC. While selecting and evaluating information systems for BOSC, managers need to look at various performance indicators, including tangibles (such as inventory level, manufacturing cycle time, defective rates, set-up time, etc.), intangibles (such as the motivation of the employees,

team work, the good image of the company, etc.), financial issues (such as profits, revenues, sales, etc.) and non-financial issues (such set-up time, product development cycle time, inventory turnover, throughput time, productivity, flexibility, etc.) measures of performance, and the overall strategic impact on the company.

7. Concluding remarks

BOSC has been emerging as a major operation strategy for improving organizational competitiveness. In the past few years, a number of articles on BOSC have appeared in academic journals, trade magazines, and the WWW. A very few articles discuss details of the design and operations of BOSC. Most discuss the experiences of Dell, BMW, Compaq, and Gateway. Nevertheless, the experiences would be very valuable for companies that aim to develop BOSC. However, most companies are not yet prepared to completely disseminate the success behind their BOSC. A review of the literature available on BOSC and on experiences of lean and agile manufacturers will be useful in developing a framework for BOSC. Although the literature survey is not exhaustive, it serves as a comprehensive base for understanding and developing a framework for BOSC. The literature on BOSC has been classified into four areas of decision-making in BOSC: BOSC and organizational competitiveness, developing and implementing BOSC, the operations of BOSC, and BOSC and information technology. Furthermore, the literature under these areas has been further sub-classified with the objective of identifying the critical factors for developing and managing BOSC.

- The following are some future research directions on BOSC.
- The development of a methodology or framework to formulate strategies for BOSC.
- The development of suitable measures of performance and metrics to measure the performance of BOSC in all of the four major areas: organizational competitiveness, developing and implementing BOSC, operations of BOSC, and information technologies for BOSC.
- The development of suitable planning and scheduling systems to manage the operations of BOSC.
- A study of the nature of scheduling and material requirements planning systems and how these can be integrated with BOSC.
- The development of a suitable information system architecture for BOSC and an IT assessment framework for BOSC.

In addition to the above, by analyzing the volume of research in each area of BOSC and also in closely related areas, we offer the following suggestions for future directions in both theoretical and applied research:

- In order to advance theories on BOSC, it will be necessary to define and specify the content domain of the BOSC construct before considering the modeling of its antecedents and the consequences of a BOSC system.
- There is no integrated model for developing a business strategy and operations strategy in BOSC that takes into consideration economic factors, market forces, and competitive factors. This is a fertile area for research, especially for M.S. and Ph.D. thesis research.
- Although numerous models and frameworks are available for managing traditional supply chain environments and production systems, these models need to be modified in order to take into account the unique characteristics of BOSC. Research is required on the implementation of BOSC.
- The application of RFID requires further investigation in BOSC, specifically on its impact and high leverage opportunities in developing and effectively operating BOSC.
- Quality control in BOSC primarily involves managing information systems and suppliers. Therefore, a suitable framework needs to be developed for quality systems in BOSC.
- Suitable measures of performance and metrics, including costing systems for BOSC, should be developed as long as mass customization is a key performance objective in winning customers and markets.
- Most of the available coordinating models deal with the traditional and narrow perspective of MPS, MRP, and CRP. However, this issue needs to be

revisited in developing models for coordinating the tasks in BOSC, as the characteristics of BOSC differ from those of TSCM and production systems.

- Issues across the clarification schema should be considered in the development of BOSC models. Since the BOSC is a global inter-organizational supply chain, this requires a model with different optimal decision variables, objective functions, and constraints. For example, the optimization of the number and location of suppliers, demand management, the optimal point at which product differentiation should take place, the time required for products to reach customers (manufacturing cycle time), and so forth. The objective should be to improve customer satisfaction with better service.
- Traditional inventory models, partnership selection models, dynamic programming, linear programming, queuing models, multi-objective criteria decision-making, and simulation can be used to solve the problems in BOSC.
- The risks involved in the design and development of BOSC needs to be studied, taking into consideration the level of uncertainties and uncontrollable factors.
- Case studies on the implementation of BOSC should be carried out on firms in the business sector to develop insights into BOSC, to understand the impact of BOSC practices, and to identify the critical factors and potential barriers for the implementation of BOSC.

At present, the authors of this paper are carrying out research on a few of the above-suggested research problems in BOSC.

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