THE ROLE OF MASS CUSTOMIZATION IN ENHANCING SUPPLY CHAIN RELATIONSHIPS IN B2C E-COMMERCE MARKETS

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ABSTRACT

Traditional supply chain management utilized traditional media and channels to link firms in linear, inefficient relationships. The advent of electronic commerce over the Internet has facilitated new relationships for connecting with new supply chain partners, thereby significantly increasing the quantity and quality of inter-organizational information flows. These information flows are theoretically evaluated using the principles of information quality dimensions. In addition, a new breed of market makers, or information intermediaries, is defining new functional relationships between the different players. The direct channel between manufacturers (or digital content providers) and consumers is enabling mass-customization, and is influencing the demand forecasting and inventory management functions. Mass customization is discussed in the context of both digital and physical goods, along with an analysis of information quality dimensions. Finally, the impact of these new supply chain information flows on industries and macroeconomic conditions is discussed.

1. Introduction: Traditional Supply Chain Management

The traditional view of the supply chain is that of a network of entities through which material flow from suppliers to consumers. Increasingly, managing the bi-directional information flows that make feasible the material flows is being recognized as an important aspect of managing the supply chain. Lummus and Vokurka (1999) stress the importance of the managing the information flows between partners in a supply chain. Dugal et al. (1994) state, "The supply chain for a manufacturer begins with a consumer, who creates demand for the products, and ends with the ingredients and packaging supplier."

Prior to the arrival of e-commerce technologies, the communication of this demand information had to go through many layers of intermediaries before finally reaching the manufacturer. The resultant distortion at each layer lead to degradation in the quality of the information needed to manage the supply chain. For instance, large variances in demand information would lead to poor production scheduling and inefficient allocation of resources (Lee et al., 1997). It resulted in the maintenance of buffers in the form of excess capacity and inventory throughout the chain.

In the traditional supply chain, raw materials providers sell to component and subassembly manufacturers, who sell to final assembly manufacturers, who distribute their products through wholesalers, distributors, dealers, and retailers to the final customers. Typically, firms employed various transportation technologies (trains, trucks, etc.) to distribute their output "downstream" to wholesalers, distributors, dealers, and retailers. This distribution channel or "outbound logistics" (Porter, 1985) may include multiple links along the way. At the same time, a firm would manage the interaction process with its upstream suppliers or "inbound logistics," which may include hundreds of firms along several links in the supply chain. For instance, giant manufacturers, such as the Ford Motor Company, manage relationships with thousands of individual supplier companies. This entire series of business entities involved in meeting the customer's demand is called a supply chain.

In the industrial era, most manufacturing companies were vertically integrated, owning their own sources of supply and channels of distribution. Freight carriers (mostly trucks and trains) were heavily regulated and prices were not competitively determined. In the 1970s, companies began to focus on their core competencies, and freight carriers were deregulated in the US, resulting in the outsourcing of the supply function and distribution channels. Many firms began to use third-party logistics providers. But most firms utilized inefficient communication between themselves and these new suppliers and distributors. Currently, there is a transition to a third era for supply chain management. Firms attempt to integrate their information systems to their suppliers and to their suppliers' suppliers, as well as their downstream partners. In some cases, they can interact directly with customers.

A primary objective of traditional logistics management was the minimization of "the total cost of transportation, warehousing, inventory, order processing and information systems." (Stock and Lambert, 1987) Progressive supply chain management encompasses the planning, directing, and controlling of the flow of products, services, and information from a firm's suppliers' suppliers to its customers' customers, through intermediaries such as distributors and retailers. (Anderson, et al., 1997) The purpose is to coordinate activities "across the supply chain to create value for customers, while increasing the profitability of every link in the chain." (Anderson, et al., 1997) This coordination aspect brings in the important, but largely ignored, role of *information flows* that complement the *physical flows* in the analysis of the supply chain.

The arrival of e-commerce has separated the *information about the product* from the *product itself* (Kaplan and Sawhney, 2000). For instance, a consumer shopping for an automobile can now use autobytel.com to gather information regarding the product and then go to a linked retailer to test drive and ultimately purchase the auto. Autobytel in this case is a new form of an intermediary that is at the hub of an *information network* connecting the various car manufacturers, consumers and dealers. The onus of maintaining timely, consistent and accurate information is now on the infomediary as well as the manufacturers.

This paper bridges this gap in the literature by identifying and analyzing the new informational flows that are leading to new kinds of relationships in the e-commerce marketspace. These information flows may represent orders, invoices, request-for-quotes, demand forecasts, transfer of digital goods, compensation in the form of digital payments, or other communication. The focus is on all forms of information flow, including those occurring in entirely new business forms and new electronic marketplaces. We demonstrate, by means of three specific examples, how the advent of web-based e-commerce technologies is altering the information flows between the traditional players in the supply chain. Our analysis suggests that firms that strategically comprehend and maximize the impact of these new information flows will be in a position of competitive advantage in the emerging networked economy.

The remainder of the paper is organized as follows. Section 2 introduces the three dimensions of supply chain management and argues that the information dimension is the most critical dimension. It ultimately contributes to the success of supply chain management by fostering dynamic relationships with partners both upstream and downstream. This argument is further substantiated in Section 3 by analyzing the information flows in the phenomenon of mass customization in business-to-consumer (B2C) markets. Section 4 concludes the paper with summary and discussion of the positive impact of non-linear information flows on supply chain efficiencies and overall business cycles.

2. The Role of Information in Supply Chain Management Relationships

Traditionally, supply chain management consisted of three distinct dimensions -- the actual physical distribution of tangible ("hard") goods with inbound and outbound logistics systems, the exchange of currency or payment, and the exchange of information between various economic players. Figure 1 indicates advances in each dimension of the supply chain. The physical distribution (or "goods exchange") dimension has been radically altered by the introduction of online exchange for digital goods and by the introduction of widespread global third party logistics systems for hard goods (Lieb, 2000). The currency exchange dimension has become a component of the information exchange dimension as firms conduct exclusively digital payments. The information dimension has undergone the most significant reengineering with the evolution of entirely new market models enabled by technological developments.

The historical view of supply chain management has focused on the creation of business processes that facilitate the supply of all necessary inputs and the distribution of all outputs in a timely and efficient manner. Prior to the arrival of web-based technologies, based on widely accepted communication standards, the supply chain suffered from inefficiencies of communication and allocation. A heterogeneous mix of communication media such as paper mail, fax, telephone and email was used to carry out the succession of activities that resulted in the final delivery of goods or services to the consumer. Limited automation in the form of EDI was available to the larger players over

proprietary and non-scalable networks. Understandably, this led to translation losses, and also placed linearity constraints on the kinds of upstream and downstream relationships in which firms could engage.

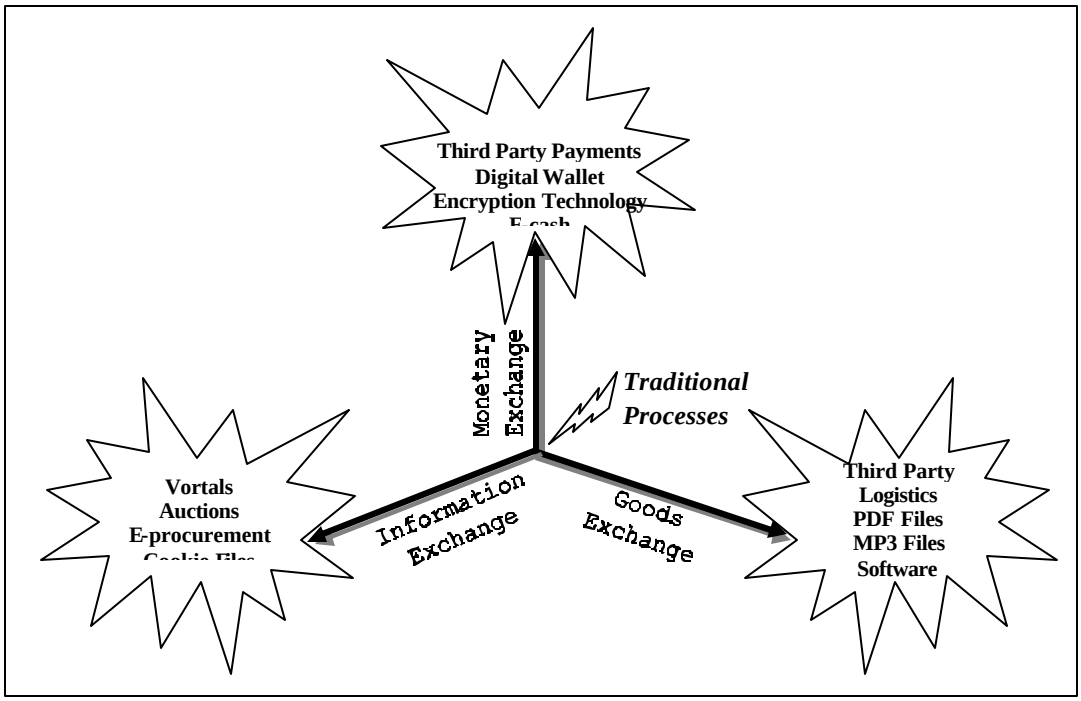

Figure 1. Three Dimensions of Supply Chain Management

The information flows in this traditional logistics environment were linear from one firm to its immediate suppliers (upstream) or immediate distributors (downstream). Producing firms typically had a fixed number of suppliers with whom they were connected. They were not connected directly to the consumer, but had to go through a series of intermediaries -- wholesalers, distributors, dealers, and retailers.

Information beyond one link in the chain was constrained by lack of formal relationships and did not convey efficiently through the links due to a lack of standard data representation schemes. In other words, while Ford and GM might advertise to the general buying public, their ability to understand characteristics of demand came directly from their dealer network or from consumer surveys or estimates. In the same manner, Ford or GM might share production planning information with their immediate suppliers, but not with their suppliers' suppliers. The lack of formal relationships and standard data representation schemes made automated sharing of production schedule data impossible beyond immediate supply chain partners. Such inefficiencies in the supply chain led to uncertainties in demand management at the firm level, which ultimately rippled their way onto the entire economy. In Section 4 we discuss the positive macro-economic impacts of the widespread adoption of web-based technologies for information transmission and standards for information representation.

The advent of electronic commerce over an open-source, ubiquitous Internet Protocol (IP) based network has facilitated the integration of the varied media that connect the supply chain, leading to significant new inter-organizational information flows that facilitate supply chain management. Web-based technologies remove the constraints of geography, time and space and thereby make feasible the creation of *value webs*. In such webs, customers drive the formation of flexible, dynamic networks by their demands and firms can engage in forming real-time links with a globally dispersed base of partners. Through these value webs, firms can provide customers with tailored products and solutions, delivered inexpensively (or free) and very quickly. This leads to increased efficiency and profitability for the firms involved and for the economy as a whole.

One significant constraint remains. Each economic player (suppliers, manufacturers, distributors, etc.) use distinct data representation schemes to electronically record information about their product characteristics, inventory levels, availabilities, forecasts, sales policies, payment policies, return policies, etc. Without a universal method for representing all information related to economic exchange activity (pre-order comparison information, order information, order-fulfillment information, and post-order feedback), the IP protocol is unable to facilitate

effective value webs. A universal scheme, based on eXtensible Markup Language (XML) is required in order to realize the full potential of this technological revolution. XML, with its standardized metadata representation capability, simplifies the exchange of supply chain information and enables automated supply chain processes. The widespread adoption of standards for information representation will result in order of magnitude benefits to the firms, industries, and economies that pursue them. Already, there have been significant advances in the development and acceptance of XML-based standards in numerous industries. (Levitt, 1999; Udell, 1999)

For example, the Chemistry community has developed CML (Chemistry Markup Language) for defining, among other things, the molecular structure of compounds. It will become the *lingua franca* of chemical information transmission. Similarly, MathML is used to transmit mathematical expressions over the Internet. "There are also XML initiatives underway that will transform the exchange of graphics data. It would not be surprising … to see a mark-up language emerging in every field." (Spedding, 1999) Thus, the true potential to empower all economic players in a supply chain depends greatly on the efficiency of information exchange, which in turn necessitates a common standard for the representation of all product and service attributes that can be easily transferred and interpreted across the World Wide Web.

Another characteristic of information exchange between supply chain partners is the evolution from limited information sharing environments to rich information sharing. Porter's Five Forces Model (1985) describes the relationship between a firm and its suppliers and buyers as a power struggle characterized by bargaining leverage and various threats. The general perception of managers was that sharing rich information with suppliers would give them too much power in the relationship, and therefore many supply chain relationships witnessed limited information exchange. In the New Economy, many firms create very open information exchange environments, consistent with their perspective that the relationship is a "win-win" game, where the successes of a firm's supply chain partners benefit the firm. Rather than acting to transfer costs to upstream and downstream supply chain partners, today's market environment encourages firms to work "in close coordination … to optimize the flow in the entire supply chain." (Mohanty and Deshmukh, 2000)

The factors that determine information quality vary from one supply chain environment to another, and this in turn impacts the management objectives of firms engaged in supply chain management. The dimensions of data representation quality, data value quality, and data model quality include many distinct quality attributes that influence the overall value of information (Yoon, et al., 2000). For example, the data value quality dimension has attributes of completeness, accuracy, currency, timeliness, precision, reliability, consistency, and relevance (Fox, et al., 1994; Huang, et al., 1999; Redman, 1992). In certain supply chain management environments, the attribute of timeliness is paramount, while in other situations, the attribute of precision may be more important. When rich supply chain management relationships are built on a foundation of IP protocol platform technologies, the partners can utilize this infrastructure to ensure the highest quality for the specific targeted attributes. Timeliness can clearly be enhanced, consistency is strengthened with robust web-based database standards, and accuracy can be improved.

The next section describes the role of information in the B2C direct channel with respect to mass customization. The final section evaluates other trends in e-commerce and supply chain management, and looks to the future.

3. Mass Customization in Business-to-Consumer Markets

The widespread adoption of the IP protocol network has spawned entirely new electronic market models commonly called marketspaces (Rayport and Sviokla, 1994). These fundamentally new markets, enabled by standardization of *information transmission*, have, in turn, spawned dramatic new business relationships with important new information flows. However, with respect to *information representation,* we still have considerable lack of standards, as discussed below.

In the B2C commerce exchange, a recent process of disintermediation (using the web platform) has created entirely new "direct channel" opportunities. Firms such as Dell.com and Amazon.com have created huge markets for selling their products directly to the consumer, by bypassing the traditional intermediaries (see Figure 2). The benefits of this new relationship are many. First, there is a significant cost savings to be realized by selling directly to the final consumer, thereby allowing the seller to lower the price(s) of its goods. Second, the seller can create a purchasing experience that perfectly meets the needs of the consumer. For sellers of tangible products ("hard goods" such as computers or automobiles), disintermediation has led to mass-customization of production. Third, sellers of digital goods (such as software, news, music, images, or financial information) have been able to bypass traditional intermediaries and deliver exactly the information that the final consumer wants.

One of the promises of the electronic commerce is that businesses will be able to offer consumers customization on a scale unlike ever before. As shown in Figure 2, the web serves as a disintermediator by replacing the intermediary links in the traditional supply chain with a direct channel to the consumer. If done correctly, this can lead to lower costs for the consumers, and improved service at the same time. Nissen (1999) describes the

architecture of a multi-agent approach to supply-chain disintermediation. By lowering the communication costs between the businesses and the consumers, the web facilitates a one-to-one interaction, which was not feasible earlier. As a consequence producers get better signals regarding the consumers' preferences and demand levels, which in turn leads to better inventory management and production planning. This disintermediation of the supply chain complements the advances made in the 90's in the area of lean manufacturing and JIT inventory control, with the overall result of lower information asymmetries in demand management activities of firms.

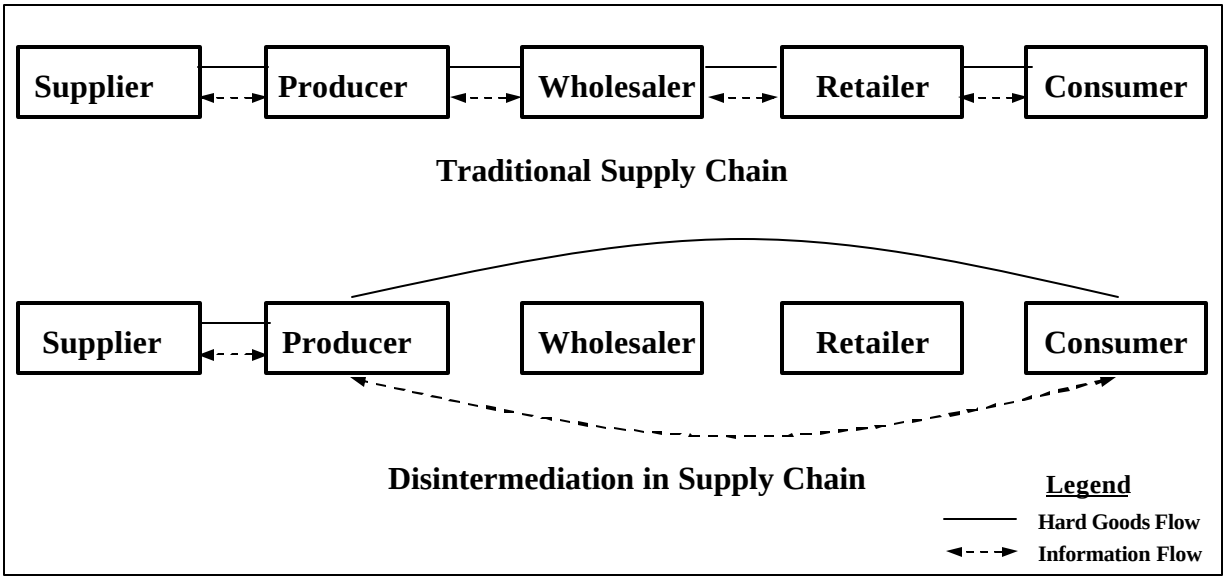

Figure 2. Disintermediation in the B2C Supply Chain

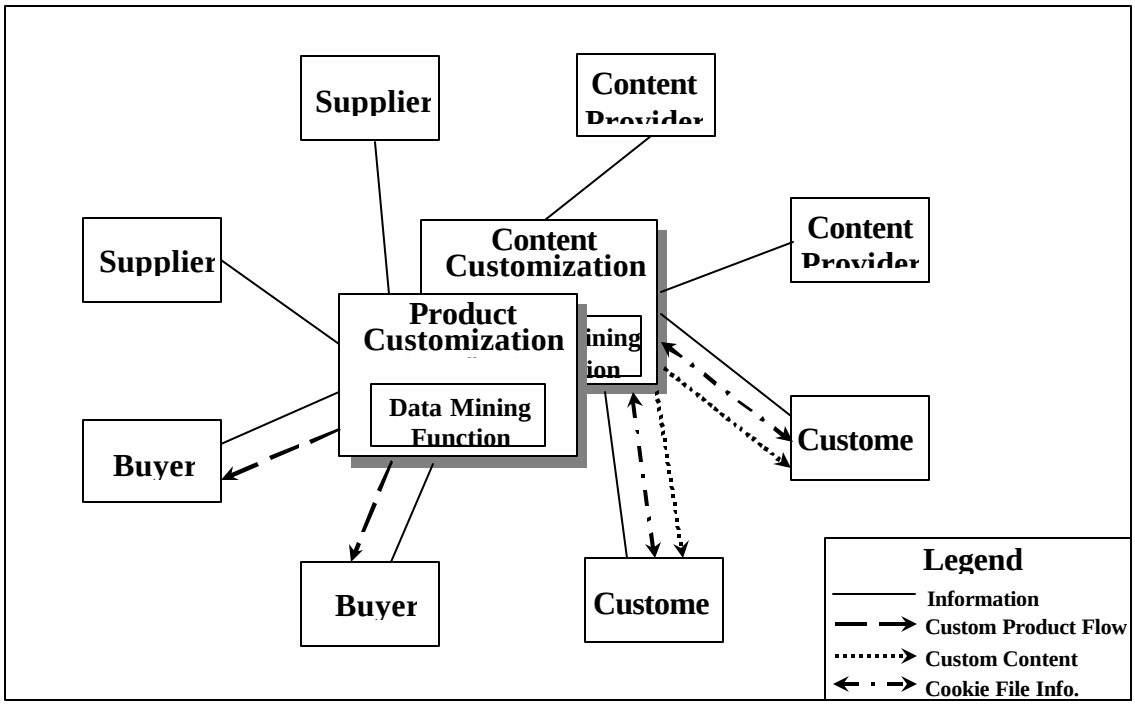

Figure 3. Exchanges in the Information Dimension of B2C Mass Customization Processes

The phenomenon of mass-customization is observable in a variety of physical and digital goods and services sold over the web. (See Figure 3.) For instance, merchants like Dell.com allow consumers to design their own

computers on their website, which is tightly connected to the JIT manufacturing operation which customizes the assembly of each order. Procter & Gamble launched Reflect.com with the notion of giving consumers a personal online beauty boutique where individuals can create their own make-up, skin care, and hair care products. Similar initiatives are being launched by Chipshot.com for ordering custom golf equipment and by Ford and GM for ordering custom cars. GM recently announced they plan to transform themselves from a build-to-stock company to a build-to-order company, thereby cutting in half the $40 billion of parts and unsold cars that exist at GM today. (Simison, 2000) They plan to reduce the total delivery time (from the time of the order) from 8 weeks to 11 days. Figure 3 portrays the bi-directional flow of information between the manufacturer of custom products and the buyers, along with the physical flow of custom products (outbound logistics).

Digital content providers can similarly provide customized products for their direct consumers. The IP environment has enabled new marketspaces and new business models designed for the direct delivery of digital goods to consumers. In the past, software was usually sold through inefficient retail outlets with expensive packaging and no customization for individual consumer needs. Many software vendors now offer downloads of their products from websites, and the trend is toward leasing of applications from remote third parties, known as application service providers (ASP), on an as-needed basis. Music is also undergoing a dramatic distribution channel transformation, with the widespread availability of MP3 content and players enabling *custom publishing* for the first time. (See MP3.com for more information.) Similarly, financial reports, legal information, news, and other textual information can now be purchased on an as-needed basis in downloadable PDF format from thousands of websites. Further, such digital content can be custom configured for each user's requirements through the use of cookie file technology. Figure 3 portrays the bi-directional information flows between digital content providers and customers, including explicit requests for content, automated cookie file information flows for customization, and download of digital content itself. For example, many portals enable each individual client to customize the portal screen (see My.Yahoo.com), thereby showing weather for that user's home town, his preferred news categories, his favorite sports teams, and his personal stock tickers to watch. Other digital content providers use direct two-way information flows to sell customized digital products to their traditional and to new consumers. For example, images (clipart libraries such as ArtToday.com or IconBazaar.com and others) and digital movies can be directly downloaded without the need for traditional logistics networks for delivery.

The information quality dimension of completeness (Yoon, et al., 2000; Fox, et al., 1994; Huang, et al., 1999; Redman, 1992) are paramount for any transactional environment, where an entire order must be entered, along with order meta-data, such as shipping and billing addresses, payment information, order confirmation, and so forth. Without complete information, either party to the transaction can terminate or abort the digital transaction. For custom digital news, information currency is important. For custom orders for hardware, such as from Dell.com, accuracy of configuration information is critical.

Seybold (1998) discusses the importance of maximizing the impacts of the various touchpoints that a firm has with its customers. The mass-customization phenomenon, where consumers are directly able to reveal their preferences to the manufacturers who in turn fulfill this demand, represents an outer limit of the maximization of the impact of these touchpoints. In essence, custom-order websites such as those offered by Dell.com are *mega-touchpoints* which must carefully be crafted and whose impact can be tremendous.

Given the low barriers-to-entry in the web-based B2C markets, the above-mentioned examples demonstrate that firms that are able to utilize web-based technologies to create smooth information flows and directly connect to consumers are better positioned to gain long term competitive advantage. These firms exploit the technological capabilities of the IP network environment to create new market opportunities. By providing customized products and content, they improve the value proposition for their customers and suppliers, while improving their overall profitability.

4. Summary and Discussion

Traditional supply chain management consisted of three distinct dimensions -- the actual physical distribution of tangible ("hard") goods with inbound and outbound logistics systems, the exchange of currency or payment, and the exchange of information between various economic players. Electronic commerce has facilitated significant revolutions in each dimension.

Electronic commerce has redefined the distribution of all goods which are (or can be made to be) digital, such as software, music, documents, images, movies, and other information. Hard goods must still be delivered by traditional transportation methods, but with the introduction of the direct channel of communication between consumers and manufacturers, the innovative manufacturer can now mass-customize the production process by reacting to the demand differences of individual buyers. Information exchange has experienced a dramatic transformation to the extent that entirely new business forms and new marketspaces have risen in the last two years,

such as online auctions and vortals or B2B eHubs. Further, the traditional payment systems are becoming just another aspect of the information exchange dimension.

The current technological revolution is creating new opportunities for further improvements in supply chain management. Electronic linkages have enabled firms to fundamentally alter supply chain relationships by enabling transaction cost reduction through electronic handling of orders, invoices, and payments. They also facilitate reduced inventory requirements and vendor managed inventory programs. (Anderson, et al., 1997) Emerging information technologies such as data mining and configurable intelligent agents also will play an important role in facilitating improved information exchange between supply chain partners. (Warkentin, et al., 2001; Sugumaran, et al., under review)

The improved information coordination capabilities of today's technological infrastructure are facilitating improvements in global third party logistics. Global satellite communications systems, global positioning satellite (GPS) systems, and the ubiquitous Internet have enabled shippers to track individual cargo containers anywhere anytime. As companies increase the trend toward outsourcing their inbound and outbound logistics, even in the global arena (Lieb, 2000), efficient exchange of logistics information between shipper, third party logistics provider (carrier), and buyer is enhanced, leading to streamlined production planning systems and reduced inventory requirements.

The emergence of entirely new dynamic electronically-mediated marketspace models has had (and will continue to have) significant impacts on 1) internal functions and profitability of individual firms (micro-economic effects), 2) relationships between and among traditional and new economic players (buyers, seller, intermediaries, etc.) within many individual industries (industrial organization effects), and 3) overall information flows, prices, and cycles in the national and global markets (macro-economic effects). Within firms, dynamic market-clearing prices enable more efficient inventory levels as they develop new electronic relationships with supply chain partners. This is making certain industries more efficient overall, which is leading to price reductions in many specific markets for goods and materials. As individual industries become more efficient, there is an impact on the overall economy.

Supply chain information flows traditionally were linear flows from one firm to its immediate suppliers (upstream) or immediate distributors (downstream). Information beyond one link in the chain was constrained by lack of formal relationships and did not convey efficiently through the links due to a lack of data representation schemes. This information gap and asymmetry led to delays, and distortions in demand information up and down the supply chain, which led to uncertainty in the production planning systems of most firms. When trends were detected in demand levels or prices, firms often over-reacted in their response. They produced too much or too little, they raised prices too quickly or too slowly, or they hired too many or fired too many workers. In the aggregate, the result of millions of economic players over-reacting to changes in the supply chain information stream was an era of recurring considerable macro-economic business cycles.

But the elimination of the inefficiencies in information exchange brought about by the dramatic new connectivity within the nation's suppliers, producers, distributors, dealers, consumers, and financial institutions has ushered in an era of reduced business cycle levels. While there may continue to be economic impacts resulting from raw material price changes (OPEC oil pricing, for example) or from political upheaval (even in the post-Cold War era), the primary cause of business cycles may become minimal due to the changes in the information dimension of supply chain management.

This paper highlights the role of information in the management of supply chain relationships. It describes the various attributes of information such as accuracy, timeliness and consistency and examines the relative importance of these in three e-commerce enabled emerging supply chain relationships. Mass-customization websites such as those offered by Dell.com are shown to be *mega-touchpoints* that have a far greater impact on a firm's bottom-line than traditional touchpoints. This lowers the number of touchpoints in a supply chain, and promotes the adoption of standards for data representation. Both of these in turn lower information inconsistencies and improve the overall efficiency of the supply chain.

Finally, this paper describes the rise of new marketplace models and the resulting new players and information flows. The theory of information quality dimensions of completeness, accuracy, currency, timeliness, precision, reliability, consistency, and relevance are applied to these marketplace models. Porter's Five Forces Model is re-evaluated in light of the emerging supply chain environment. The ubiquitous presence of web-based open protocol technologies is driving new economic relationships and new market opportunities for information utilization. These new information flows, if properly utilized, can enable new efficiencies in the management of the supply chain, provide new opportunities to provide greater value to the consumers by facilitating the dynamic creation of value webs, and have a positive impact on the overall economy.

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