Recalibrating Demand-Supply Chains for the Digital Economy

Arun Rai
e-Commerce Institute
Robinson College of Business
Georgia State University
Atlanta, GA 30080
arunrai@gsu.edu
Web site: http://rai.eci.gsu.edu

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Abstract

Firms are integrating segmented supply chains to improve global resource coordination and reduce buffers, such as lead times and inventory levels. Yet, supply chain integration, if inappropriately conceptualized, can have a detrimental impact on market responsiveness and value generation capability. Transformational innovations in Internet technologies, e-business models, such as consortia-sponsored e-markets, and industry process standards, such as *RosettaNet*, are challenging assumptions of value creation and appropriation. As a consequence, firms and supply chain sets need to reevaluate supply chain processes and enabling digital capabilities. Five supply chain configurations, i.e., integrated firm, fragmented chains, end-to-end integration, modular chains, and solution webs, are profiled. Assumptions and capabilities associated with each configuration are discussed. Key transformation issues in moving from one configuration to another are evaluated. Some directions for future research are offered.

Keywords: supply chain configuration, e-coordination, supply chain transformation, demand fulfillment

INTRODUCTION

Disruptive technologies falsify assumptions sacred to business models. The Internet and inter-related e-innovations are challenging assumptions underlying established patterns of organization, coordination and value-creation. By redefining the reach, range and richness of information processing and exchange, these e-innovations are challenging the traditional organizing logic of markets, hierarchies and firms. Supply chain configurations represent complementary capabilities required to execute value propositions embedded in business models of firms and their partners (Milgrom and Roberts, 1990). Growing demand fulfillment expectations in the marketplace, coupled with advances in coordination technology, make it imperative to re-evaluate supply chain configurations and their economics. Senior management needs to confront two inter-related questions. First, *what* value-added roles will their organizations play in existing and potential supply chain sets? This question focuses on *business concept* innovation (Hamel, 1999). Second, *how* will the organization achieve its value proposition? This question confronts operational execution of the business concept.

Activities conducted within the confines of traditional organizational boundaries can now be distributed across a dynamic mix of short- and long-term partners. As a result, competition is increasingly across supply chain sets, not single organizations (Evans and Wurster, 1999). This shift in the unit of competition requires a strategic re-framing of business models, partnerships, investments, and management of technology and capital assets. It requires a reassessment of *what* digital resources are generated and *how* these digital resources are used to leverage physical, financial and intellectual resources across the extended supply chain. Incumbents and startups must re-examine their value propositions and business-to-business coordination patterns used to achieve them.

The Internet economy generated 830 billion dollars in 2000, which is a 58 percent increase over 1999 (Whinston, et al., 2001). Business-to-Business e-commerce has experienced substantial rapid growth rates with accelerating trends projected. The Internet unleashed entrepreneurial efforts in the development of infrastructure and applications resulting in high-levels of investments and growth in these segments of the digital economy. Advances in Internet-protocol (IP) based technologies are redefining inter-enterprise global connectivity, process and data integration, bandwidth and real-time information sharing. These digital technologies are fueling e-business model innovations for markets and commerce. Independent, private, and consortia-sponsored e-marketplaces provide alternative mechanisms for procurement and sales; supplier enablement applications promise to reduce constraints impeding real-time, multi-agent, collaborative product design; global coordination capabilities of third-party logistics providers raise questions about fulfillment efficiency and productivity of assets maintained by firms for fulfillment purposes.

The *potential* returns from business-to-business commerce innovation are phenomenal across virtually every industry and sector (Ford and Durfree, 2000). Firms are directing large investments toward their supply chain infrastructure and processes with expectations of realizing gains in efficiency and responsiveness (Lee and Whang, 1998). Yet, limited understanding exists about alternative supply chain configurations and their alignment with market and demand characteristics leading to erroneous strategy formulation and implementation. There is also inadequate knowledge of how errors in configuration choices are detected and corrected and how capability gaps required to implement a configuration are addressed.

I address four key questions in this paper. First, what are the drivers compelling a rethinking of supply chain configurations? Second, what are the dominant patterns of supply chain configuration, and how do these configuration patterns differ in their value creation assumptions? Third, what e-coordination capabilities are required for the execution of each configuration? And, finally, how should supply chain transformations be managed?

SUPPLY CHAIN TRANSFORMATION DRIVERS

Business models are being differentiated by assumptions and mechanisms used to sense and fulfill complex demand patterns. Inefficient *product push* supply chains operating in predictable demand markets need to be transformed to achieve steady flows from suppliers to customers. Ineffective product push supply chains operating in dynamic markets need to be transformed to responsive *solution pull* supply chains. The weaknesses of supply chain configurations are being tested by discontinuities in fulfillment expectations, value chain roles, e-coordination innovations, and design and transformation knowledge. I briefly discuss each of these discontinuities.

Discontinuities in Fulfillment Expectations

1. Companies continue to loose sales due to poor market mediation, i.e., misalignment between downstream supply flow and upstream demand flow. Lost sales opportunities for products with short product life cycles and high contribution margins, such as state-of-the-art Personal Digital Assistants, lead to revenue and customer losses. Close substitutes are just a click away and customers demand just in time fulfillment of their needs.
2. Order complexity continues to increase with customers specifying solution requirements, as opposed to passively selecting from displayed pre-configured offerings. They expect a total solution that fits their specific requirements. Fulfilling demand for complex solutions requires real-time coordination across massively distributed supply networks of long- and short-term partners.
3. The debate on clicks versus bricks is now passé. Initial e-commerce euphoria centered around website construction and debating complete substitution of traditional channels with online channels. Companies need to strategically formulate the relationship between their online and offline operations for multi-channel environments.

Discontinuities in Value Chain Roles

1. In industries with a high installed product base relative to new purchases by consumers, such as automobiles, revenues and margins are migrating downstream towards after-sales service activities (Wise and Baumgartner, 1999). Firms playing a traditional upstream role in such industries are facing eroding margins, which is forcing them to rethink value creation assumptions.

2. Different patterns of consolidation are occurring in different industries. The electronics components industry has seen substantial distributor consolidation with the top 25 distributors controlling 85 % of distributor sales (Merrill Lynch Report, 1999). The paper and building products industry has seen massive consolidation of manufacturers and customers with distributors getting squeezed in the process.

Consolidation shifts roles and margin structures requiring a reassessment of business models and value-added activities conducted in the supply chain.

Discontinuities in e-Coordination

Historically, disruptive technologies in transportation and distribution systems, such as railroad, shipping, and trucking, and information and communication technologies, such as the postal system, telegraph, and pre-internet computing, substantially lowered coordination costs and the organizing logic for value creation. Complementary e-innovations in standards, solutions, and e-business models, are driving down internal and external coordination costs precipitously, challenging assumptions about the economies of scale and scope of a firm's value-added activities. Consider the following:

1. Industry-wide standards initiatives, such as *RosettaNet* in the Information Technology and Electronics Components industry and *HL7* in the healthcare industry, are increasing the efficiency of business-to-business integration. Standardized data definitions and partner interface protocols (PIP) enable application integration and process coordination across firms. Arguably, these initiatives increase process efficiencies and reduce switching costs.
2. A powerful set of Internet-based event-driven, coordination solutions is emerging. Modular, parameterized solutions for supply chain management, customer relationship management, and enterprise applications, enable efficient inter-organizational coordination patterns heretofore infeasible. Integration solutions, such as *.Net* from Microsoft and middleware technologies, reconcile applications and databases within and across organizational boundaries. M-commerce applications are eliminating location constraints for information resources and its users. e-solutions, such as middleware, make it feasible to integrate segmented information resources. The boundary spanning orientation of these solutions raises questions about the usefulness of focusing managerial attention to resource within traditional boundaries!
3. Independent, buyer- and supplier-sponsored e-markets are being rapidly established for material, repair, and operations (MROs) goods and operating inputs. These online markets offer to streamline market inefficiencies by bringing together far-flung suppliers and buyers. They extend a value proposition of lowered coordination cost, improved service, and effective fulfillment.

Discontinuities in Design & Transformation Knowledge

Disruptions in core technologies challenge assumptions about fundamental processes, resources required for them, and their organizing logic.

1. A transformation from integral designs to modular designs enables postponing product differentiation to downstream stages. It enables superior alignment of supply with demand where the market values product variety. However, changes to modular product designs must be considered, in tandem, with redesign of supply chains, which are responsible for order management, fulfillment, and revenue management.
2. Leading information content businesses are using versioning, product divisibility, plummeting distribution costs, and close-to-zero reproduction costs, to fulfill differentiated customer needs and enhance value generated by effective price discrimination. Similar models are being adapted in service industries, such as Application Service Provisioning, and news and entertainment, where the entire customer fulfillment experience can be executed digitally.
3. Discontinuities in transformation knowledge falsify knowledge-based assumptions of firms, including stalwarts. The very reasons of success become the biggest liabilities. For example, the human genome project raises questions about the imminent liability of capital-intensive R&D labs in leading pharmaceutical companies (Christensen, 1997). Voice over Internet Protocol (VoIP) communication technology threatens to transform large capital assets into big liabilities for telecommunications companies.

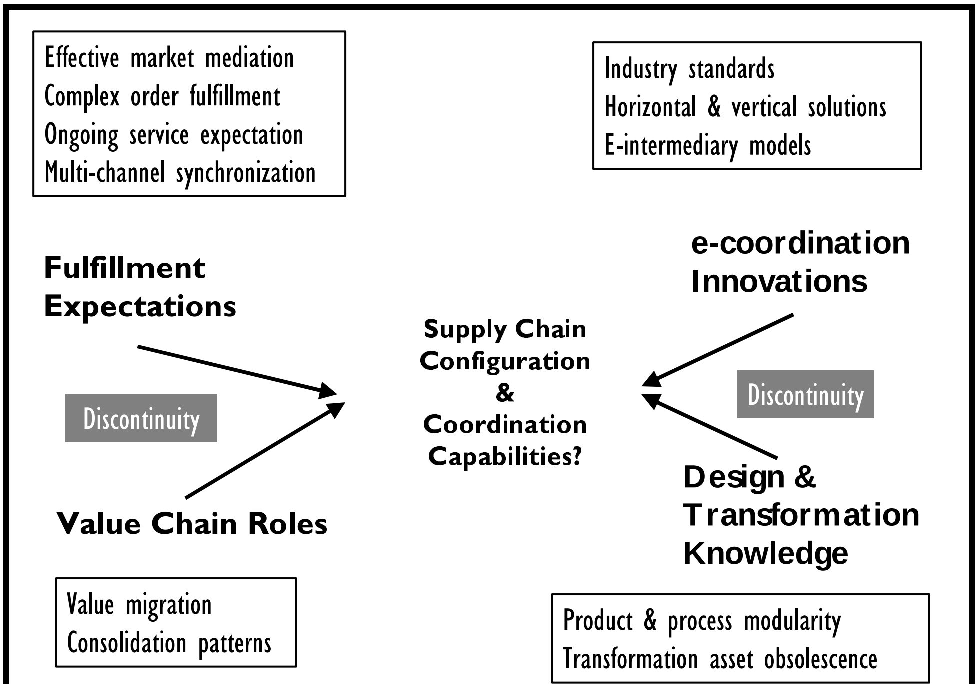

Figure 1: Supply Chain Transformation Drivers

VALUE CREATION ASSUMPTIONS IN SUPPLY CHAIN CONFIGURATIONS

The knowledge-based theory of the firm suggests that the core capability of a firm's business is to create, exploit and renew knowledge assets (Grant, 1996). Supply chain configurations differ substantially in their assumptions about the demands for knowledge creation and their organizing logic create and exploit knowledge. As a result, they require dramatically different internal and external coordination capabilities. Figure 2 schematically contrasts the configurations in terms of their broad fulfillment perspective, ranging from product push to demand pull, and organizing value-creation logic, which can be oriented towards the firm, markets, hierarchies or networks.

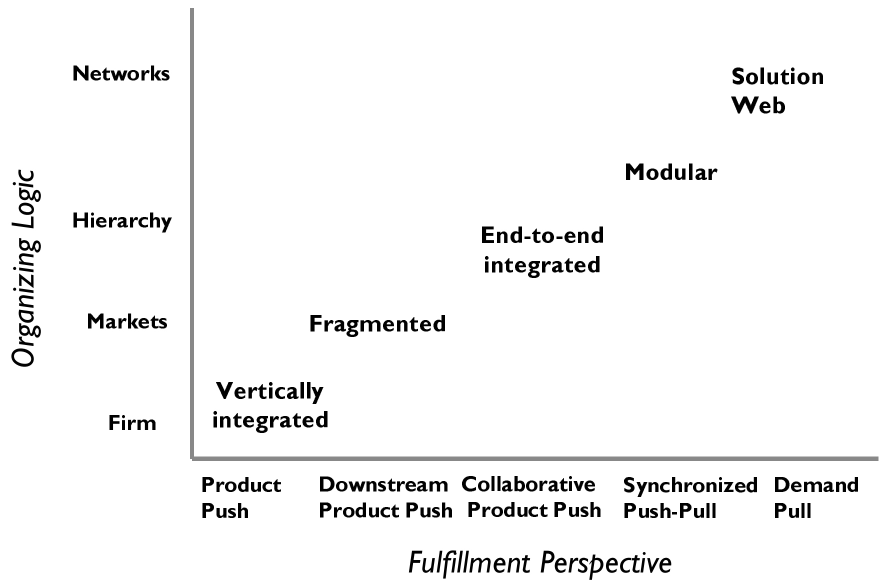

Figure 2: Supply Chain Configurations

I now compare and contrast each configuration's knowledge-based assumptions and value-creation perspective and then proceed to examine their required coordination capabilities.

Configuration #1: Vertical Integration

The enterprise is viewed as the competitive unit of analysis. Knowledge pertaining to products and services is created within the firm's boundaries or internalized through mergers and acquisitions. Tightly coupled knowledge characterizes product design and process design. Massive capital assets are accumulated to support the firm's value chain activities. As a result, high fixed costs versus variable costs characterize the business model. Capital productivity is achieved by spreading resources of key activities, such as product design, production, transportation, warehousing, and distribution, over large product volumes. Assumptions about high transaction risks and external coordination costs minimize contracting with suppliers.

Resource utilization and revenues are sometimes enhanced through diversification in related or unrelated initiatives (Dewan, et al., 1998; Hill, 1988; Palepu, 1985). Unrelated diversification involves distinct inputs, processes, and outputs. Resources consumed and contributions generated by each unit are *pooled.* Related diversification, on the other hand, involves complementary product lines. Leveraging human, digital, and physical resources across complementary product lines requires managing complex reciprocal interdependencies.

Ford Motor Company used to manufacture tires and owned rubber plantations that provided raw materials for tire production. Producers of movies and other forms of entertainment content owned distribution outlets, such as theaters. Computer companies, such as IBM, produced integrated solutions, which required them to produce peripherals, key subsystems, operating systems, and application software. Several power companies own their generating facilities, transmission lines, and distribution networks.

Companies operating under less integrated supply chain structures sometimes revert to forward integration in response to a downstream shift of supply chain power and the customer value proposition. Coca-Cola has aggressively acquired downstream distributors and bottling plants so as to *control* supply chain segments closest to customers. Ford has engaged in a similar move by acquiring some of its dealer networks.

Configuration # 2: Fragmented Chains

The channel is characterized by fragmentation between suppliers, manufacturers, distributors, and retail firms. The firm depends on its internal resources to develop knowledge about products and services. Limited product and process knowledge is jointly created with channel members.

Supply chain fragmentation can stem from inadequate interorganizational information processing ability. Alternatively, as suggested by game theory (Freidman, 1986) and agency theory (Ross, 1973), conflicting objectives promote firms to maximize their benefits at the expense of others. The enterprise is viewed as the competitive unit of analysis and major competitors include upstream and downstream firms in the value chain. Zero-sum game strategies, such as massive price discounting, forward buying, diverting, and lack of information sharing, are used to fiercely compete with upstream and downstream players (Clemons and Row, 1993).

Companies, such as Campbell Soup, which are characterized by *predictable and stable demand patterns*, observed that resource planning for production, distribution, transportation and warehousing was unpredictable causing supply chain-wide inefficiencies and stockouts and stockpiles (Fisher, 1997). Procter and Gamble observed a similar problem in their diaper supply chain. These companies addressed their supply chain inefficiencies by integrating key processes, such as forecasting and capacity planning, across the supply chain.

Configuration #3: End-to-End Integration

Under this configuration, an integrated supply chain perspective replaces an enterprise-centric mindset. Coordination knowledge is collaboratively generated and applied to improve supply chain planning and execution. Competitive pressures make it infeasible for firms to remain economically viable by incurring high market mediation costs caused by inefficient operational execution. In competitive environments, less than stellar fulfillment takes a massive toll on revenues, customer acquisition and retention, and operating costs (Kamalini and Speakman, 2000). Several e-tailers, such as *eToys*, have suffered due to poor fulfillment, as have retailers like *K-mart*. Did you know that a box of cereal spends about 104 days in the supply chain? Supply chain-wide operational inefficiencies in order management, fulfillment of goods and services, and revenue management, are systematically addressed.

Configuration #4: Modular Chains

Under this configuration, a modular structure is applied to products, processes and supply chain resources so as to enable quick integration with resources and capabilities of partner organizations (Strader, et al., 1998). Modular systems are characterized by loose component coupling. Low interdependency leads to high recombinability enabling heterogeneous inputs to be recombined into a variety of heterogeneous configurations thereby increasing product variety (Schilling, 2000). A modular product design is complemented with shared architectural knowledge (Sanchez, 1997; Sanchez, 1999). Parameterized modules further enhance product variety. Modular chains enhance supply-side alignment with unpredictable demand patterns. They are designed to promote distributed innovation, while realizing coordination gains enabled by modular product and process designs (Matthew, 2000).

Parallel innovation experiments are triggered, as suppliers engage in modular innovations while adhering to pre-specified interface constraints (Baldwin and Clark, 1997). Such coordinated knowledge co-creation improves response to dynamic and varied customer requirements. Information technology companies, such as Cisco, Dell Computers, Hewlett-

Packard and Sun, deploy a modular strategy in their conceptualization of products and accompanying supply chain processes. They have used the mix-and-match approach of modules to exponentially increase product variety, postpone differentiation, and enhance alignment of offerings with customer requirements.

Companies, such as UPS' e-Logistics group, SAP, i2, and Siebel systems, among others, offer parameterized and modular software products that can be configured to meet client requirements. The product design reduces constraints of a pre-defined implementation sequence; solutions can be rolled out module by module, in sequences that align with customer capability and need.

Configuration # 5: Solution Webs

Solution webs deliver integrated solutions that match customer needs without using an integrated business model. These webs form around key customer requirements for products and services. Platforms provide the business architecture to plug in business processes from different vendors and customers and integrate complementary competencies (Ciborra, 1996). Participating in solution webs requires disaggregating product and process knowledge and embedding them in multiple solution webs, thereby increasing *points of presence*. By embedding key capabilities into multiple solution webs, firms can enhance network externalities and experience increasing returns to scale (Arthur, 1996; Evans and Wurster, 1999). This focus is in sharp contrast to a consolidation and hierarchical mindset of *meet all your needs under our roof*.

Customers are increasingly interested in specific solutions for their needs. Traditional boundaries, such as supplier's product categories, channels, and industry classification, are essentially choice constraints from the customer's perspective. Webs of companies that span traditional boundaries come together to configure solutions that meet customer requirements. Some companies are in long-term relationships; others aggregate capabilities dynamically to seize a market opportunity.

Consider the following illustrations where companies have identified a demand and moved rapidly to establish complementary partnerships and fulfill this demand. By disaggregating and repositioning its capabilities to distribute continuous flow products, Enron has established a market for bandwidth distribution. By partnering with content aggregator, Blockbuster, it is entering into distribution of video on demand. In additional to distributing content to its audiences through cable television networks, CNN, in partnership with Akami technologies, now distributes programming content in a streaming video format for Internet channel users. Not withstanding the important copyright issues surrounding Napster's business model for music distribution, a mismatch has been highlighted between distributing *track-by-track standardized CDs* and *track-by-track configurations* aligned with requirements of specific consumers.

Consider the case of Cisco Systems, which aggressively pursues an acquisition strategy, especially of startup companies, to support the evolution of its knowledge base. It has also developed value-added partnerships with downstream companies, such as Ingram Micro for order management, assembly and selected services. In addition, it constantly seeks out new complements that enhance its ability to sense and fulfill demand. Cisco orchestrates its solution web's value proposition by dis- and re-aggregating knowledge through acquisitions and partnerships (Tapscott, et al., 2000). Its evolving pattern of distributed knowledge assets is comparable to a distributed cognition system.

Finally, consider the dynamic strategy pursued by Vodafone to deliver customized wireless solutions in the marketplace. In 1999, Vodafone acquired the German telecommunications company, Mannessman AG, for U.S. $ 180 billion in stock, after a bitter takeover battle. In addition, Vodafone and Airtouch merged in June 1999 to create the world's largest international mobile communications company. In September 1999, Bell Atlantic and Vodafone Airtouch Plc announced an agreement to create Verizon Wireless that brought together the wireless assets of these organizations, so as to rapidly create a common digital technology and build a strong brand. The merger between these companies led to the rapid development of the world's first international wireless access protocol (WAP) that enables globetrotters to access their intranet data without placing long-distance data calls back to their home countries to access WAP services. Verizon also developed contractual relationships with British Sky Broadcasting to deliver sports, news, and entertainment content over WAP and short messaging services. In effect, Vodafone pursued a dual strategy of consolidating selected knowledge integration activities, including new product development, within the firm. It also pursued market-based relationships to integrate the products of Vodafone's knowledge-based activities, such as WAP-based phones, with other firms' products, such as British Sky Broadcasting.

Table 1 compares and contrasts the value creation perspectives underlying the five supply chain configurations.

Supply Chain Configuration					
Properties	**Vertically Integrated**	**Fragmented**	**End-to-End Integrated**	**Modular Chains**	**Solution Webs**
Unit of Competition	Firm	Firm	Supply chain	Supply network	Solution networks
Strategic Focus	Value chain control	Coercive supply chain gaming	Cooperative buffer reduction	Mass customization and postponement of differentiation	Points of presence for customer need fulfillment
Product- & Process-Knowledge Integration	Tightly coupled within the firm	Tightly coupled within the firm	Tightly coupled supply chain planning & execution knowledge	Separation of modular & architectural knowledge.	Separation of modular, architectural and platform knowledge.
Resource Complementarity	Achieved within firm boundaries without partners	Achieved within firm boundaries and with short-term partners	Achieved with long- & short-term supply chain partners	Achieved with long- & short-term supply chain partners	Achieved with long- and short-term supply chain partners & customers
External Coordination	Non-existent	Non-core activities.	Supply chain planning & execution	Innovation; supply chain planning & execution	Platform development & dynamic knowledge integration
Asset specificity	Low transaction specific assets	Low transaction specific assets	Transaction specific assets for supply chain planning/execution	Transaction specific assets for product design & supply chain planning/execution	Transaction specific assets for dynamic knowledge integration & supply chain planning/execution
Contracting Rationale	Transaction cost & risk	Transaction cost & risk	Predictable service levels	Innovation capability & predictable service levels	Complementary platforms & problem-solving competencies

Table 1: Value Creation Perspectives of Supply Chain Configurations

Configuration #1: Vertical Integration

Operational coordination is focused on reducing operational risks and optimizing processes within the firm by generating efficiencies within and across its value chain activities. Product diversification increases the need for internal coordination and the demands for coordination are greater for related diversification, in comparison, due to reciprocal interdependencies.

e-coordination solutions are applied to support the building and protecting of firm-specific assets, reducing transaction uncertainty, and supporting low frequency external transactions. Under this framework, information technology is deployed to achieve production economics and drive down internal coordination costs. For example, automated teller machines (ATM) expanded service channels while increasing teller availability and resource productivity. Manufacturing innovations, such as flexible manufacturing systems and cellular manufacturing, reduced production setup time and its variation, and enhanced resource productivity for multi-product lines. Computer Aided Manufacturing (CAM) uses information systems to program, direct, and control production equipment in the fabrication of manufactured items (Voss, 1986). Computer Integrated Manufacturing integrates design, manufacturing, and business functions so that shared information resources are created to support a coherent, integrated organizational system (Cox and Blackstone, 1983). These Advanced Manufacturing Technologies have been shown to improve a firm's production efficiency, while constraining market-responsiveness (Brandyberry, et al., 1999).

Functional application suites, workflow applications, business process reengineering tools, intranets and enterprise resource planning applications are illustrations of technology initiatives launched to streamline internal process design and their information sharing practices. Owens Corning adopted an ERP system to replace 211 legacy systems! Multi-enterprise ERP systems can be calibrated to manage the resource relatedness among different lines of business. Hewlett-Packard maintained business unit anatomy in its ERP implementation, while Dow Chemicals implemented an integrated ERP solution to achieve resource sharing across complementary business lines (Davenport,).

Configuration#2: Fragmented Chains

Resource optimization decisions for key activities are carried out within enterprise boundaries. There is limited investment in transaction specific capital, as these resources have limited salvage value in other contexts (Williamson, 1975). Limited investments in interorganizational coordination, coupled with objective differences between firms, encourage strategies to create information asymmetries. Segmented inter-organizational systems constrain *substituting* information flows for physical stocks, such as inventory. Lack of sharing demand information, such as real-time downstream order data, causes the *bullwhip effect*, where minor variations in customer demand are amplified upstream in the supply chain (Lee, et al., 1997; Riggs and Robbins, 1998). Volatility in demand caused by zero-sum game practices, coupled with lack of information for decisions, leads to supply chain-wide coordination inefficiencies (Clemons and Row, 1993). Safety stock requirements are exaggerated at each stage in the upstream supply chain. Market-mediation costs are common even for functional products with stable demand functions, such as diapers, resulting in stockouts, stockpiles, fixed and working capital inefficiency, and poor customer service. Segmented inter-organizational systems constrain supply chain-wide management of yields, global customer accounts, and receivables and payables (Margretta, 1998b). E-coordination solutions, such as EDI and web-based EDI systems, are essentially applied to automate existing information flows and reinforce decision structures and roles.

Configuration#3: End-to-End Integration

Sharing Information for Multi-echelon Resource Optimization

Retailers share point-of-sales data with distributors and manufacturers so as to improve inventory management and reduce market mediation costs (Fisher, 1997). Distributors share information about retail orders and capacities, and in rare occasions even cost structures, with manufacturers who, in turn, use this information for capacity planning and production scheduling decisions. Such information sharing practices enables implementation of lean practices and a balanced flow of goods and services through the system.

Collaborative forecasting and replenishment, vendor-managed inventory, quick response, and efficient customer response are used to streamline buffers, such as exaggerated upstream safety stocks, across the supply chain. Multi-echelon planning of production, inventory and distribution, coupled with tight inter-firm process coordination, enables optimal staging and movement of goods through the supply chain (Mentzer, 2001). For example, McKesson, a leading pharmaceutical distributor, has its contractual relationship with pharmaceutical retailer CVS based on fill rates and, in essence, efficient vendor-managed inventory. McKesson has established a key coordination role for itself by balancing supply by manufacturers, such as Pfizer and Eli Lilly, and demand faced at retail outlets (Kalakota and Robinson, 1999). In some cases, such as the popular Wal-Mart and Procter & Gamble relationship, the logistics and fulfillment responsibilities were shifted to the manufacturer. By having access to Wal-Mart's detailed sales and inventory information, P&G achieves steady flows through the system.

Leveraging Interdependent Flows

Companies, such as Cisco and Li & Fung, have developed deep competencies in generating digital assets, and then using them, to optimize physical and revenue flows across massively distributed global operations (Margretta, 1998a). These companies barely touch physical products during the fulfillment process. Instead, they develop and manage processes that coordinate flows of information, revenue and physical products through the supply chain. By achieving visibility of production capacity, schedules and inventory holdings, optimal decisions are made from a supply chain-wide perspective. Given the importance of supply chain visibility, third-party logistics providers are investing substantial resources in their digital infrastructures and bundling sophisticated e-coordination solutions along with traditional transportation and warehousing solutions (Lee and Whang, 1998; Margretta, 1998a).

Eliminating Embedded Structural Constraints

End-to-end supply chain integration is not limited to optimizing physical, information, and revenue flows within existing network constraints. Developing supply chain-wide efficiencies requires a review of end-to-end supply chain fulfillment objectives, network structure, and dynamic patterns of information, product, and revenue flows across the network. Pricing and discounting practices that distorts demand, especially for functional products like soap and diapers, needs to be remedied. Process improvement techniques, such as activity-based costing, can be applied to detect inefficient links, such as redundancies in distribution and warehousing capacity, inventory bottleneck points, and segmented information systems.

Consider Saturn's after-sales service strategy (Cohen, et al., 2000). Saturn has implemented a distributed coordination system between dealers and central operations. This system is in contrast with most auto manufacturers, who continue to use a centralized structure where parts are shipped from a central location to requisitioning dealers. By having real-time access to dealer-level inventory and production schedules, shipment decisions can be triggered to move parts between dealer locations, as necessary. Responsiveness to unpredictable demand patterns and reductions in transportation, inventory and warehousing costs, have been achieved across the supply chain. By optimizing after-sales service operations across the network, in contrast with dyadic links with individual dealers, Saturn has excelled in after-sales service performance.

Integrating Multi-Channel Operations

As bricks-and-mortar companies re-define their mix of clicks-and-bricks, they need to re-configure logistical and operational capabilities for multi-channel environments (Gulati and Garino, 2000). Consider the case of CVS and its online channel, CVS.com, which received the *2000 Best in E-commerce Systems Award* for its integration of web and bricks-and-mortar systems to provide customers with a complete online pharmacy solution (Hohl, 2000). The clicks-and-bricks business model is based on tight coordination of ordering and fulfillment operations between CVS.com and CVS' 4,100 stores across the country. In addition to providing standard or next day delivery of prescriptions, over-the-counter medications, and health and beauty products, customers can choose to place online orders and pick them up at the nearest CVS store. Channel separation-integration decisions need to be complemented with pricing and discounting decisions. Differential pricing structures between online and offline channels can promote cannibalization and should be coordinated to generate desired surpluses from each channel operation.

Enabling e-Solutions

Implementing integrated supply chains requires developing the *reach* and *range* capabilities of IT infrastructures (Broadbent, et al., 1999). *IT reach* determines the connectivity between distributed buyers and suppliers. *IT range* determines application support for supply chain planning and execution.

Dedicated solutions, such as EDI, work well in establishing connectivity and supporting information sharing between long-term, high transaction volume relationships. EDI linkages between automobile manufacturers and their first-tier suppliers lower shipping discrepancies (Srinivasan, et al., 1994), expedite payment recovery, reduce order processing errors, and cut down transportation, inventory and operating costs (Mukhopadhyay, et al., 1995). However, implementation and communication costs make traditional EDI a less attractive for medium- and small-sized companies with low volumes and transaction frequencies (Fu, et al., 2000). Web-based Internet EDI enables business transactions by using Java-capable browsers that can be used to establish information sharing links while eliminating the need for traditional EDI-related applications. This technology makes it economically feasible for small and mid-sized companies, such as second- and third-tier suppliers, to establish electronic integration with their trading partners.

Achieving supply chain visibility of orders, pick-pack-ship, returns and service requests requires implementation of supply chain execution applications. Coordinating internal resources with supply chain operations requires integrating supplier-facing applications and internal transaction applications, such as ERP systems. In addition, implementing event-based and workflow-enabled supply chain applications can optimize coordination between distributed processes (Yang, 2000). For example, an online order automatically triggers pick-pack-ship, billing and inventory update transactions. Supply chain planning applications possess sophisticated modeling capabilities, which when coupled with data generated by execution applications, can be used to dynamically optimize procurement, production, inventory, transportation, and warehousing decisions.

Private, neutral, and consortia sponsored e-markets offer value propositions to streamline transaction and coordination inefficiencies associated with MRO and operating input procurement. Automating and reconciling procurement processes, including requisitioning, ordering, invoicing, payment, shipment, order tracking and receiving, can generate substantial cost savings.

Configuration #4: Modular Chains

Rationalizing Multi-Echelon Modular Buffers

As with end-to-end integrated chains, leveraging interdependent flows, achieving supply chain-wide visibility, multi-echelon resource planning, supply chain-wide constraint analysis, and deep logistics partnerships are key practices for successful modular chains. Yet, there are critical considerations to be kept in mind to avoid misappropriating lean practices associated with end-to-end chains. Modular chains are designed for fulfillment of innovative products that are characterized by rapid innovation, modular product designs and volatile demand patterns, which require supply chain flexibility (Fisher, 1997). On the other hand, functional products, which are characterized by integral product designs, stable demand patterns and low innovation rates, require efficient supply chains.

Only too often, companies end up over-emphasizing lean practices to a point where they squeeze out critical buffers creating an unresponsive supply chain. In such situations, brilliant product designs and business models will remain just that in the face of poor order fulfillment. E-tailers, such as e-Toys, have faced criticism for their poor fulfillment, as has Compaq recently for its inability to fulfill massive demand for its popular *iPAQ* handheld device. Multi-echelon resource planning for buffers recognizes inherent unpredictability of demand patterns and the importance of planning buffers through the entire system. Staging buffers effectively through the system can bring down the costs of flexibility. For example, inventory can be rationalized at the component level, as opposed to finished goods, to reduce carrying costs and hedge against vulnerable forecasts on specific product configurations.

Balancing Supply-Demand with Modular Logistical Coordination

Distributors transform their traditional break-bulk role to a complementary service role where they collaboratively work with contract manufacturers for product assembly. By acquiring technical knowledge from manufacturers, retailers and distributors offer after-sales services, such as modular product upgrades and service contracts. Close partnerships are used to manage reciprocal interdependencies between production, assembly, transportation and distribution.

Consider the following situation. Within six months of initiating its alliance with UPS Logistics Group, Ford Motor Company has shaved vehicle transport time by 26 percent, or four days. A precision web-enabled system, Autogistics, reduces assets clogged in the supply chain and cuts inventory carrying costs. By the end of 2001, the system will be operational in the US, Canada and Mexico. Ultimately, UPS Autogistics will provide complete visibility into 21 Ford Motor assemply plants, 4 rail centers and 55 destination ramps, which provide delivery to 6,000 Ford, Mercury and Lincoln dealers.

Third-party logistics (3PL) solutions providers have invested significant resources in their e-coordination capabilities and the market for 3PL providers has been expanding dramatically (Matthew, 2000). Manufacturers, such as Apple Computers and Dell, use the digital and physical networks of third-party logistics providers, such as UPS and Fritz, to meet fulfillment objectives. They have developed sophisticated coordination systems to stage components and subsystems from the supply to the demand side without pre-configuring stocks that are misaligned with market requirements. They are using partnerships with logistics partners that can be used to increase inventory velocity through practices such as channel assembly of final configurations.

Rationalizing Supply Chain-Wide Modular Assets

As firms evaluate supply chain-wide resource complementarity, they need to reassess capital assets and governance structures. Governance and cost structures of non-core assets requires special scrutiny. Non-core, capital-intensive assets are not scalable, drag down capital productivity, and require disproportionate operations and maintenance expenditures. There has to be a compelling reason to retain such drag assets within the firm's cost structure. Outsourcing decisions can be made to improve process performance and capital productivity.

Enabling e-Solutions

The integration e-solutions discussed earlier can be used to support the information processing needs of modular chains as well. There are some important distinctions in their configuration and deployment. Modular chains require modular processes, which, in turn, require modular application architectures. The reciprocal interdependencies between distributed modular processes make it important to use web-based event driven architectures to support the commerce functions.

Certain information and knowledge-based resources are friction-laden and not easily shared across organizational boundaries. These resources pertain to specialized modular knowledge and supporting processes and applications within the organization. Consequently, some organizations are institutionalizing internal coordination-intensive IT structures around a narrow band of firm competencies and complementarities while using external coordination-intensive IT structures to source other capabilities. Transaction specific e-coordination solutions, such as Autogisitcs in the UPS-Ford relationship, can be developed to support tightly coupled partnerships and build relational dependencies. Ingram Micro has leveraged its world-class systems and infrastructure to generate value for manufacturers, resellers and itself in the dynamic global technology distribution business. The company co-creates knowledge with manufacturers about product assembly and configuration. It co-creates order management knowledge in concert with resellers. Ingram has established a state-of-the-art online ordering system, which enables resellers to generate and transmit quotes to end-users, and locate, order, and ship products. It has established financial services that enable resellers to exploit market opportunities. By dynamically managing supply chain-wide assets, fulfillment, and partner roles, Ingram Micro effectively integrates the supply capabilities of 1,700 manufacturers and the shifting demand patterns of its 175,000 resellers.

We are seeing general-purpose e-solutions offered by application service providers that are contractually available for common business processes. Consider the case of Biztro.com, a third-party solution site for small-business transactions. It provides a range of services such as accounting, consulting services, creative services, finance, human resources management, insurance, legal, training, technical services, and travel. Request for proposals are submitted by completing online forms. The company offers a value proposition that enable firms to shift several elements of sales, general and administrative expenses from a fixed cost to a variable cost structure. By scaling such activities and using the Internet for coordination, companies, like Biztro.com, purport to achieve efficiencies in their cost structures.

Given unpredictable demand patterns in several modular product industries, supplier capacity management tends to be a harrowing problem. Exchanges enabling supply-side asset swaps that enable dynamic resource management across fragmented suppliers are now emerging (Wise and Morrison, 2000). Contrasted with auctions that promote aggressive supplier-against-supplier bidding with a downward pressure on prices, these exchanges allow fragmented suppliers to trade capacity and pool purchases, thereby creating a more efficient supplier base.

Configuration #5: Solution Webs

Coordinating Multi-Party Reciprocal Transaction Architectures

Business models are determined by aggregating transactions that create value, while revenue models are determined by aggregating transactions that appropriate value (Amit and Zott, 2000). Embedding processes into multiple solution webs requires that transaction architectures be designed to support the unique pattern of reciprocal interdependencies represented in each solution web. Such an embedding strategy results in an exponential increase in the transaction architecture complexity for business and revenue models. Consider, for example, UPS eCommerce Solutions Group, which has embedded its e-Returns solution into the business and revenue models of customers, such as Buy.com. These portals and their allies, such as UPS, are pooling complementary transaction capabilities for demand fulfillment. By embedding selected solutions into multiple online portals, UPS is “plugged” into multiple value-creating and value-appropriating architectures. Similarly, consider the recent alliance between Seattle-based premiere specialty coffee company, Starbucks and last mile convenience item aggregator, Kozomo.com. Kozmo’s value proposition is to fulfill the entire convenience experience for movies, food, basics, and specialty items. It uses Starbucks vast retail outlet to receive customer returns, as customers can drop off movies at conveniently placed Kozmo return boxes at their neighborhood Starbucks. Kozmo provides the platform to integrate partners and their processes. Solution web platform providers must establish a stellar digital architecture to support the transaction architecture requirements of supplier- and customer-facing processes.

Implementing Visible Platform Architectures

The Open Source Movement (OSM) that led to the development of the Linux system provides a sharp contrast to the "closed" platform strategy pursued by companies, such as Microsoft. As the Linux source code is openly distributed, service providers can evolve their complementary and, for that matter, competing offerings to capitalize on platform changes. The core assumption underlying the OSM is straightforward. Having complementary products evolve rapidly increases the solution quality available to consumers. The impact of the open source movement is impressive, as leading IT solutions providers, such as IBM Global Services, are offering service capabilities around the Linux platform. By adopting an open source approach, the community of Linux developers is igniting positive feedbacks and network externalities for the fulfillment of IT solutions.

Coordinating Inter-generational Innovations

The success of solution webs depends, in part, on process and product knowledge integration. Inter-generational knowledge must be coordinated so as to avoid diminished customer value and harrowing experiences. Consider, for example, a customer who is a Digital Subscriber Line (DSL) from an Internet Services solution web and is attempting to upgrade their operating system from Windows 98 to Windows 2000. Some DSL services providers have taken several months to support a transition from Windows 98 to Windows 2000. In essence, users could not transition to Windows 2000 if they wanted to retain their DSL services! Solution webs can fall out of favor if they ineffectively respond to marketplace innovations that impact the fulfillment experience of their customers.

Enabling e-Solutions

Industry standards initiatives, such as *RosettaNet* in the IT and electronics components industries and *HL7* in the healthcare industry, are establishing partner interface protocols (PIPs) to integrate supply chain-wide applications for key processes. By standardizing on product dictionaries for millions of stock-keeping units (SKUs), a big hurdle to information exchange is being addressed. These innovations reduce external coordination costs and reduce setup costs for partnerships. Complementary initiatives, such as e-market and B2B hub integration solutions, are being applied to establish reference platform architectures and reusable software patterns that can be used to support the transaction architectures for solution webs.

Table 2 summarizes the e-coordination capabilities for the five supply chain configurations.

SUPPLY CHAIN CONFIGURATION					
Properties	**Vertically Integrated**	**Fragmented**	**End-to-End Integrated**	**Modular Chains**	**Solution Webs**
Fulfillment focus	Repeatable, predictable & efficient fulfillment of standardized products	Sporadic fulfillment of standardized products	Repeatable, predictable & efficient fulfillment of standardized products	Responsive, anticipatory & effective fulfillment of innovative products	Responsive, anticipatory & comprehensive fulfillment of customer requirements
Interdependencies	Firm-focused pooled, sequential & reciprocal interdependencies	Uncoordinated sequential & pooled inter-firm interdependencies	Predictable sequential inter-firm interdependencies	Responsive sequential & reciprocal inter-firm interdependencies	Responsive pooled, sequential & reciprocal inter-firm (supplier & customers) interdependencies
Process optimization focus	Firm's value chain activities	Firm's value chain activities & transaction costs	Multi-echelon SC planning & execution	Multi-echelon synchronization of supply- and demand-facing processes	Multi-echelon knowledge integration for dynamic fulfillment
Logistics & distribution role	Push products into market. Focus on transportation and movement.	Breaking bulk & risk pooling	Continuous flow of information, revenue & products	Expedition of upstream demand flow & downstream supply flow	Integration hubs for supplier- & customer-processes. Focus on capability integration.
Flow coordination	Internal coordination of information, physical & financial flows	Batched inter-firm, dyadic coordination of information, physical & financial flows	Real-time supply-chain wide coordination of information, financial & physical flows	Real-time supply- & demand-chain coordination of information, financial & physical flows	Real-time customer requirements interpretation & supplier knowledge integration

SUPPLY CHAIN CONFIGURATION					
Properties	**Vertically Integrated**	**Fragmented**	**End-to-End Integrated**	**Modular Chains**	**Solution Webs**
Supply chain information visibility	Internal information sharing	Dyadic transactional data	Order management, fulfillment & revenue management	Architectural specifications, order management, fulfillment, & revenue management	Platform capability, complementary supplier- & customer-knowledge, order management, fulfillment, & revenue management
Information Systems Portfolio Orientation	Enterprise resource planning	Enterprise resource planning; lean external coordination systems	Supply chain planning & execution; enterprise resource planning; lean CRM systems	Supply chain planning & execution; enterprise resource planning; customer relationship management.	Platform capability for *current* & *future* supplier- and customer-applications integration
Information Systems Integration Objectives	Integration of functional applications using intranets	Lean inter-firm EDI integration	Web-based, extranet and dedicated EDI integration	Web-based, extranet and dedicated EDI integration	Web-based, extranet and dedicated EDI integration for *current* & *future* suppliers & customers
Information Exchange Standards	Firm-specified internal standards for ERP integration	Firm-specified internal & external standards for ERP & EDI integration	Supply chain-wide standards; eXtensible Markup language (XML) standards	Standardization of specialized *XML* data type definitions, such as *SML* for the steel industry, & partner interface protocols.	Standardization of *industry-spanning* data type definitions, application protocol interfaces, and partner interface protocols.

Table 2: e-Coordination for Supply Chain Configurations

TRANSFORMING SUPPLY CHAIN CONFIGURATIONS

Integrating the Demand-Supply Chain

e-Business poster child companies, such as Amazon, Dell Computers, Cisco Systems, and McKesson, have used e-coordination technologies to implement strategic partnerships, shared governance mechanisms, and information sharing arrangements that optimize supply chain-wide processes. They have adopted a global resource management focus by aligning supply with demand at all stages in the supply chain. To achieve end-to-end coordination, it is critical to bring together supply- and demand-chains by integrating supply chain management, enterprise resource management, and customer relationship management. This requires infusing e-coordination technologies, such as Web-based applications delivery, distributed and real-time transaction processing, heterogeneous data management, and decision support technologies, into the end-to-end supply chain planning and execution processes. In addition, the multi-channel integration strategy should directly inform supply chain coordination requirements that leverage related assets across channels.

If information sharing is viewed as the proverbial "letting the fox into the hen house," investments in e-coordination technologies are unlikely to yield results. Transitioning to an information sharing and collaborative decision-making mindset is a major managerial challenge, especially if a history of hostile, zero-sum war game practices characterizes current relationships. Achieving end-to-end fulfillment efficiency requires scrutiny of goal incongruence and minimization of principal-agent conflicts. Developing and implementing incentive structures, long-term contracts, and trust-based relationship management, especially for strategic services that can only be incompletely contracted reduces goal incongruence. Supplier development practices accompanying implementation of integration techniques, such as JIT, have positively impacted performances between second- and first-tier suppliers in the U.S. auto industry (Scannell, et al., 2000).

Management must ensure that e-coordination investments are reinforced, as opposed to dampened or overridden, by information sharing practices, decision structures, and relational management for incomplete contracts. Techniques such as theory of constraints and process improvement can be used to determine bottlenecks that constrain leveraging related resources across the supply chain. Figure 3 summarizes the key areas to be addressed while transitioning to an end-to-end integration supply chain.

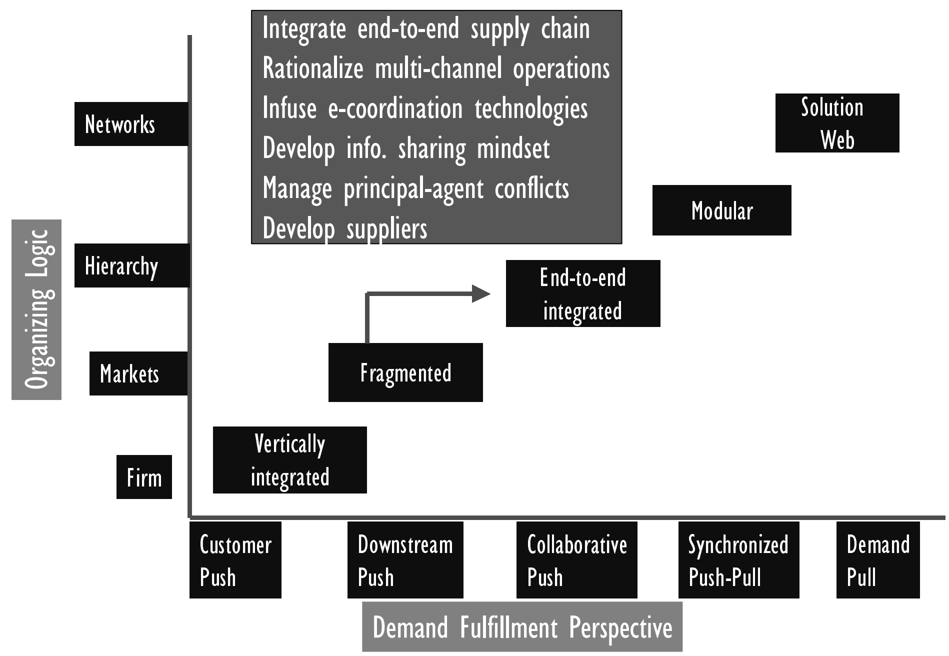

Figure 3: Integrating the Demand-Supply Chain

From a research standpoint, investigating the complementary capabilities required to infuse e-coordination capabilities into critical supply-chain wide processes, such as inventory management and product design, will inform transformation strategies to integrated e-chains. Investigating the pattern of effects between these complementary practices will provide a basis to allocate managerial resources on maximally reinforcing practices.

Modularizing the Supply Chain

Revenue models focused on transaction volume of standardized solutions see a natural erosion of profit margins. Investments in e-coordination solutions enhance productivity and create consumer surpluses. In general, IT does not seem to create sustainable profits, as supranormal returns are washed away through intensified competition and lowered entry barriers (Hitt and Brynjolfsson, 1996). As a result, some firms shift their focus from low margin, standardized products and services, to high margin, innovative and customized solutions. Such repositioning of product mix to create value requires re-configuring supply chains that work in dynamic markets. It is a major error, and one often committed, to use an efficient supply chain strategy for innovative products (Fisher, 1997).

Transitioning to responsive supply chains requires a modular reconfiguration of capital assets, products, processes, and enabling e-solutions. Several companies have failed miserably or reported substantial hurdles in redesigning supply chains due to inadequate emphasis on modularity (Fisher, 1997). Architectural product knowledge provides critical coordination information to integrate globally distributed processes deployed by specialized suppliers, contract manufactures, and distributors. Given the inherent demand volatility of modular products, it is essential to develop a multi-echelon buffering strategy. Of course, the very nature of dynamic markets provides arbitrage opportunities for aggregators and distributors. Figure 4 summarizes the key areas to be addressed while transitioning to a modular supply chain.

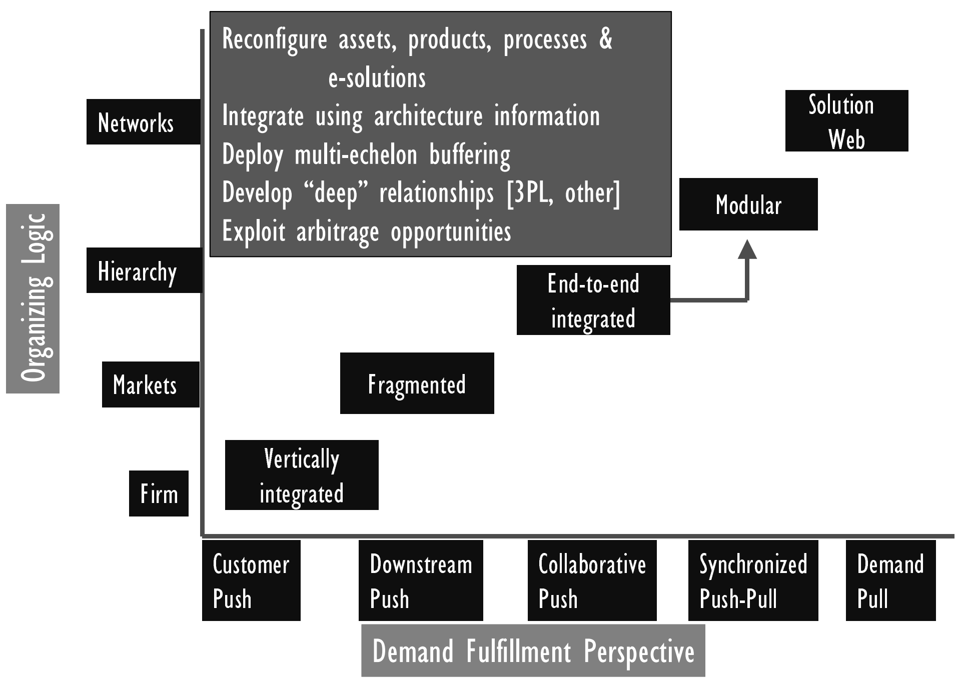

Figure 4: Modularizing the Demand-Supply Chain

From a research standpoint, enhancing multi-echelon resource planning models that considers different pricing and incentive schemes and process integration objectives continues to be a critical issue. In addition, investigating arbitrage mechanisms and game theory applications, especially as they pertain to reverse- and forward-aggregation, will provide valuable insights from a novo-intermediation perspective within dynamic markets. Benchmarking the fulfillment impacts of e-solutions in functional and modular product environments will lead to a better understanding of differential impacts of supply chain management technologies on value creation and distribution.

Loosing Boundaries: The Shift to Solution Webs

Solution webs intend to penetrate new customer segments and markets where products and service are configured to requirements and delivered to customers with near flawless execution. These webs focus on collaborative value creation, where capabilities that cut across traditional business, industry and sector boundaries need to be blurred. Being prepared to strike opportunities requires a shift to a real options perspective from a Net Present Value perspective to evaluate investment decisions (McGrath, 1997).

A platform that integrates complementary transaction capabilities of suppliers and customers and builds the business model's reference architecture is required. The flexibility of the platform to add or subtract pieces impacts the evolution and ongoing responsiveness of solution webs. Focusing on creative solutions presses the need to establish open platforms, while proprietary rights constrain such a movement. Interestingly, Linux now runs on the *widest range of vendor offerings* in the world. Given the inherent complexity of transaction architectures, contract management, revenue flows and settlement are major considerations. Some e-markets have indicated their intent to support the fulfillment of customized goods and services. These e-markets, no doubt, face formidable challenges in monitoring incomplete and evolving contracts that need to be applied to coordinate a growing buyer-supplier cardinality for configured-to-requirements services. If inadequate automation leads to excessive exception handling requiring human intervention, the scalability and revenue model of solution webs will fall apart. Figure 5 summarizes the key areas to be addressed while transitioning to solution webs.

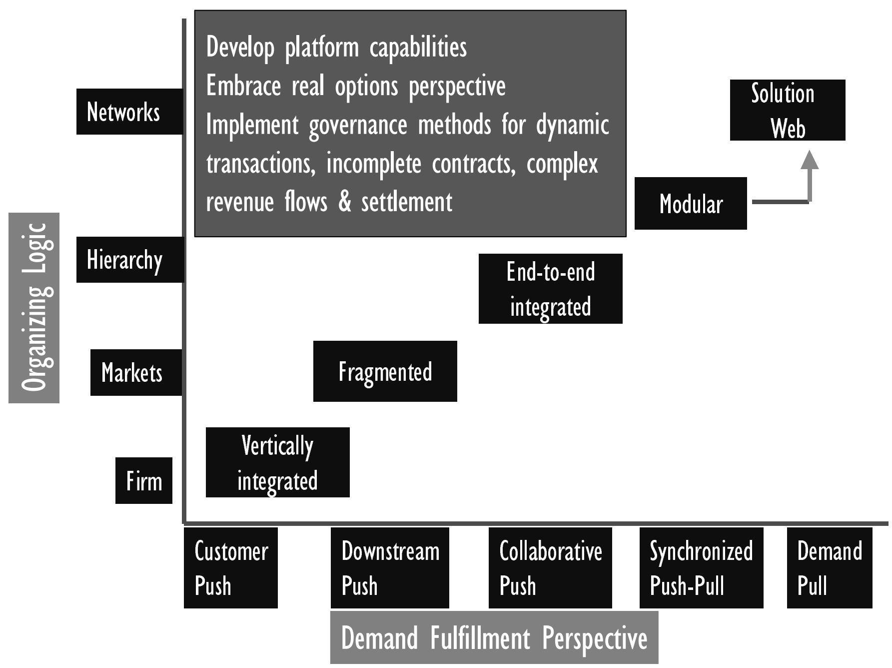

Figure 5: Transforming to Solution Webs

From a research perspective, the conceptual foundations of value creation and value appropriation in solution webs are under development and an ongoing field experiment. What are the implications of solution webs being sponsored by buyers or sellers, such as the consortia e-market movement that we are seeing? How are principal-agent conflicts managed with incomplete contracts when the solution provider does not have a unique identity? What contract management system capabilities are required to ensure scalability of solution webs? What measures of service quality are appropriate for such fulfillment models and how do these measures generate meaningful feedback?

Responding to Downstream Revenue Movement

In industries with high installed-to-new product ratios, such as automobiles, and product-based industries where the consumer experience is based on ongoing utilization of services, such as computers, revenue streams have moved towards service providers (Wise and Baumgartner, 1999). As the points of contact for service provisioning are close to customers, distributors have expanded their traditional break-bulk roles to also provide value added services and improve margin structures. Manufacturers, such as GE, focus on services, such as financing, maintenance and operation support, for their installed product base. We are seeing similar movements in the IT industry with IBM Global Services providing ongoing hosting and other ASP services, and Gateway giving away cheap personal computers and focusing revenue attention on leasing and internet service contracts. By pursuing aggressive partnerships with IT solutions providers and financiers, traditional freight-forwarders are providing configured or customized fulfillment solutions. Fritz manages the global inbound logistics process for Apple Computers by creating specialized assets that enable it to provide high service levels (Lee and Whang, 1998). By assuming such service roles, freight-forwarders have become a real threat to distributors and aggregators. It is critical that firms constantly monitor shifting patterns of value creation and appropriation within their industries and supply chains and develop proactive strategies.

Responding to Consolidation Patterns

There appears to a natural pattern of industry structural evolution (Fine, 1998). Vertically integrated firms that focus on efficiency are transformed to horizontal firms that focus on collaborative innovation. As innovations stabilize, resource efficiencies become a critical success factor for firms. IT and related technologies are applied to enhance resource productivity and improve capacity utilization. As a result, excess capacities, relative to a fixed output, are created, which lower entry barriers. Consolidation is used as a strategic move to improve production economics and capacity utilization, block backward or forward integration and raise entry barriers.

Patterns of consolidation on buyer and seller sides directly impacts captivity of buyers and sellers and how value is created and distributed across supply chains. Firms trapped in such situations need to reevaluate their roles and develop responses, such as providing value-added services or disaggregating their business model and embedding core capabilities into solution webs, much like Enron has done. Responses to buyer- and seller-consolidation enabled by e-solutions and differential responses to be pursued based on value chain position and industry membership are interesting research questions.

CONCLUDING REMARKS

Demand fulfillment focuses on establishing the business concept that creates value and then executing that concept with operational efficiency. Assumptions underlying revenue models and business architectures need to be critically evaluated.

This scrutiny requires reassessing choice of the supply chain configuration and coordination mechanisms used to support a selected configuration. A carefully crafted transformation strategy that is based on the dynamic, and sometimes overlooked relationships between product mix, product design, supply chain configuration, and e-coordination capabilities must be devised. As firms formulate their supply chain management and e-coordination strategies, they must ensure that their B2B exchange architecture provides the digital platform to define and execute short- and long-term relationships with suppliers and customers. As discussed, there are several interesting research questions that must be addressed by using an inter-disciplinary perspective. Integration of concepts from economics, information systems, operations, strategy, marketing and accounting are critical to meaningfully attack the complexities of the supply chain management phenomenon. Finally, a good transformation strategy pays great attention to change management. As a senior executive of a large distribution company put it, “You need to formulate a supply chain transformation strategy aligned with your culture. Each time you pit the two against each other, culture will eat strategy for lunch!”

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