

# Recalibrating Demand-Supply Chains for the Digital Economy

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## ABSTRACT

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*Firms are integrating segmented supply chains to improve their dynamic resource management processes 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. Innovations in Internet technologies, e-business, and process standards, such as RosettaNet, are challenging assumptions to manage resources across supply chains and to create value. As a consequence, firms need to reevaluate supply chain partners, 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 for value creation and process capabilities for resource management that are associated with each configuration are discussed. Key issues in moving from one configuration to another are evaluated.*

**Key-words:** Supply chain configuration, Digital coordination, Supply chain transformation, Demand fulfillment.

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Earlier versions of this paper were presented at the Netcentricity conference (co-hosted by Dell Corporation and University of Maryland, College Park), the University of British Columbia, Vancouver, Institut d'Administration des Entreprises de Paris, Université PARIS 1 - Panthéon Sorbonne, and the University of Oklahoma.

## RÉSUMÉ

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*Les entreprises intègrent des chaînes de valeurs segmentées pour améliorer leurs processus de gestion dynamique des ressources et réduire les tampons, tels que les temps d'avance et les niveaux de stocks. Cependant, l'intégration des chaînes de valeur peut avoir un effet négatif sur la réactivité face au marché et sur la capacité à engendrer de la valeur si elle n'est pas correctement conceptualisée. Les innovations dans les technologies de l'internet, dans l'e-business et dans les normes de processus telles que RosettaNet remettent en cause les hypothèses de gestion des ressources dans les chaînes de valeur. En conséquence les entreprises doivent réévaluer leurs partenariats, leurs processus et les technologies dans ces chaînes. Cinq configurations de chaînes de valeur, i.e., l'entreprise intégrée, les chaînes fragmentées, l'intégration de bout en bout, les chaînes modulaires et les solutions web sont esquissées. Les hypothèses de création de valeur et des capacités des processus pour la gestion des ressources qui sont associées avec chaque configuration sont discutées. Des questions clés concernant le passage d'une configuration à une autre sont évaluées.*

**Mots-clés :** Configuration de chaînes de valeur, Coordination numérique, Transformation des chaînes de valeur, Satisfaction de la demande.

## 1. INTRODUCTION

Disruptive technologies falsify assumptions sacred to business models (Christensen, 1997). The Internet and inter-related digital 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 digital 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 service expectations in the marketplace, coupled with advances in coordination technology, make it imperative to re-evaluate supply chain configurations and their economics. In this regard, firms need to confront two inter-related questions. First, what value-added roles will they play in existing and potential supply chain sets? This question focuses on business concept innovation (Hamel, 1999). Second, how will the firm 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 competition is increasingly between supply chain networks instead of single firms. 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.

From a technological innovation standpoint, 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 a driving force behind 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 process innovation are phenomenal across virtually every industry and sector (Ford and Durfsee, 2000). As a result, firms have been directing large investments toward their supply chain infrastructure and processes with expectations of realizing gains in efficiency and responsiveness (Lee and

Whang, 2000). However, firms across many different industries still face substantial deficiencies in their end-to-end processes (IBM Research Report, 2004; Rai and Sambamurthy, 2006).

To the extent that product-market characteristics are stable and predictable, consistent with neoclassical economics, the challenge for firms is to architect supply chain configurations that globally optimize resources to achieve greater efficiencies (Simchi-Levi *et al.*, 2003). In contrast, to the extent that product-market characteristics are uncertain and innovative, consistent with Schumpeterian economics, the challenge for firms is to architect supply chain configurations that sense and respond to opportunities with agility (Sambamurthy and Bharadwaj, 2000; Schumpeter, 1939).

To address the deficiencies in their supply chain configurations and capabilities, firms must evaluate how they acquire, combine, and leverage resources across supply chains (Rai *et al.*, 2006). Based on an extensive review of the supply chain literature in information systems, operations management, and marketing, Patnayakuni, Rai, and Patnayakuni (2006) conclude that there is strong evidence that characteristics of supply chain relationships impact the patterns of resource flows among partners. Based on an empirical investigation in the context of manufacturing and retail supply chains, they conclude that the relational orientation of a firm towards its supply chain partners promotes the exchange of private information between them. However, as Rai *et al.* (2006) and Patnayakuni,

Rai and Patnayakuni (2006) note, future research should examine the supply chain capabilities and resource management processes that are required for different product-market characteristics.

Given the limited theoretical understanding about alternative supply chain configurations and their alignment with product-market characteristics, there is a risk of erroneous strategy formulation and implementation of resource management capabilities. Moreover, there is also a gap in our knowledge of how errors in configuration choices are detected and corrected, and how capability gaps that are required to implement a given configuration can be addressed. Thus, we theoretically investigate the following overarching research question:

***How should firms configure and transform their supply chains to effectively compete in a dynamic business environment?***

To answer this question, we examine each of the following underlying questions:

- *What are the drivers for the reconfiguration of supply chains?*
- *What are the dominant supply chain configurations and their assumptions related to value creation and dynamism of their business environment?*
- *What digitally-enabled coordination capabilities are required for each configuration?*

- *How should transformations of supply chain configurations be managed?*

From the standpoint of informing theories, the resource-based view provides one lens to understand the role of resources in gaining and sustaining a competitive advantage (Barney, 1991; 1995; 1999) and has also been used to understand how IT can be used to create business value (Bharadwaj, 2000). However, it does not fully address the dynamic environments in which firms operate, nor the specific processes required to structure, combine, and leverage resources and capabilities (Sirmon *et al.*, 2007).

Accordingly, we draw on the theoretical perspective of dynamic resource management for value creation to understand each of the configurations, their underlying assumptions, and the role of digital technologies. In addition, we draw on transaction cost economics (Williamson, 1987; 1991), real options (Fichman, 2004; McGrath, 1997), and design of processes and products (Simchi-Levi *et al.*, 2003) to isolate properties of each of the supply chain configurations and of the capabilities for their digital enablement.

The contributions of this paper are three-fold. First, we identify the different drivers of supply chain transformation. Second, we identify the value creation assumptions and the role of supply chain resources in five supply chain configurations. Third, we compare and contrast the digital capabilities that are required for the resource management processes for the five supply chain configurations. Fourth, and

finally, we isolate the focal aspects that need to be addressed in transforming from one supply chain configuration to another.

The rest of the paper is organized as follows. In section 2, we identify and discuss four key drivers of supply chain transformation. We examine the value creation assumptions that underlie five supply chain configurations in section 3. In section 4, we identify the digital coordination mechanisms that enable the execution of different supply chain configurations. Finally, in section 5 we offer prescriptive suggestions for digitally transforming supply chain configurations.

## **2. SUPPLY CHAIN TRANSFORMATION DRIVERS**

Business models are differentiated by the underlying assumptions and mechanisms they use to sense and fulfill complex demand patterns. Inefficient *push* supply chains that operate in predictable demand markets lack steady product flows from suppliers to customers. When operating in dynamic markets, these push supply chains need to be transformed to responsive *solution pull* supply chains. However, pull-based approaches have their limitations (Simchi-Levi *et al.*, 2003). In fact, the weaknesses of these push- and pull-based supply chain configurations are being tested by discontinuities in fulfillment expectations, value chain roles, digital coordination innovations, and design and transformation knowledge (Figure 1). We briefly discuss each of these discontinuities.

**2.1. Discontinuities in Fulfillment Expectations**

Traditional fulfillment models and value chains that function as a series of linear, sequential activities are increasingly being replaced by non-linear models built on networks of relationships between firms and suppliers (El Sawy *et al.*, 1999). Yet, many firms have not been able to adequately respond to shifting fulfillment models and value chains and continue to loose sales due to poor market mediation, i.e., misalignment between downstream supply flow and upstream demand flow (Table 1). 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 as close substitutes with better fulfillment emerge. Order complexity continues to increase as customers specify total solution requirements instead of passively selecting from displayed pre-configured offerings. Fulfilling demand for complex solutions requires real-time peer-

to-peer networking among long- and short-term partners. The debate on clicks versus bricks is now passé. Initial e-commerce euphoria centered around Website construction, and whether or not traditional channels should be completely substituted with online channels. Instead, firms need to develop strategies for dealing with multi-channel environments and providing customers with a seamless experience across these channels.

**2.2. Implications of Industry Structure**

The Internet has forced changes to the structure of many industries with traditional roles in the value chain being disintermediated. In industries with a high installed product base relative to new purchases by consumers (e.g., 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

INDUSTRY	END-TO-END PROCESS DEFICIENCIES
Automotive	Deficient integration of systems and software from multiple vendors with average warranty costs per vehicle at \$700.
Electronics	Challenges in transitioning from mass production to configure-to-order supply chains that achieve productivity and customer responsiveness.
Healthcare	Fragmented processes across payers, providers, and hospitals. Poor quality of patient records. Accelerating costs and slow responsiveness.
Banking	Under-utilized data and silo structures. Diminishing customer loyalty with deficient products and services.
Retail	Fragmented systems and under-utilized information across the supply chain from track-and-trace innovations (e.g., radio frequency identification).
Telecomm	Incomplete view of customer because of fragmented systems for billing, customer care, self-service, and activation of services.

Table 1: Pervasive Need for Digitally Enabled Services for Business Processes (IBM Research Report, 2004; Rai and Sambamurthy, 2006).

is forcing them to rethink value creation assumptions.

Distinct patterns of consolidation are occurring in different industries. The electronics components industry has seen substantial distributor consolidation, and the paper and building products industry has seen massive consolidation of manufacturers and customers with distributors becoming disintermediated in the process. As consolidation causes changes in roles and margin structures, firms are reassessing both business models and value-added activities conducted in the supply chain.

### 2.3. Discontinuities in Digital Coordination

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

- 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 process integration. Standardized

data definitions and partner interface protocols (PIP) enable application integration and process coordination across firms. Arguably, these initiatives increase process efficiencies, reduce switching costs, and increase partnering flexibility.

- 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, are enabling efficient inter-organizational coordination. Integration solutions, such as *.Net* from Microsoft and middleware technologies, reconcile applications and databases within and across organizational boundaries. Mobile commerce applications, such as radio-frequency identification (RFID), eliminate location constraints for information resources and its users. These boundary spanning digital solutions illustrate the need for firms to focus on resources both within and beyond traditional firm boundaries.
- Independent, buyer- and supplier-sponsored digital markets have emerged 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.
- Developments in service-oriented architecture (SOA) enable reuse of

macro-level software services instead of the traditional focus on reuse of micro-level objects. SOA is designed so that loosely coupled services can be used to manage business processes. Since SOA is platform independent, it can be used to reconfigure and adapt business processes among peers in a network. By adopting an SOA architecture, firms can more quickly adapt to changes in demand and lower overall coordination costs with business partners. (Papazoglou and Georgakopoulos, 2003).

#### **2.4. Discontinuities in Product Design & Innovation Process**

Disruptions in core technologies challenge assumptions related to production, distribution, and innovation, the resources required for each of them, and their organizing logic. A transformation from integral designs to modular designs of products and services enables postponing product differentiation to downstream stages allowing 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 (Sanchez and Mahoney, 1996; van Hoek and Weken, 1998).

Leading information content businesses are using versioning, product divisibility, plummeting distribution costs, and close-to-zero reproduction costs (Shapiro and Varian, 1998;

Shapiro and Varian, 1999), 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 (ASP), and news and entertainment, where the entire customer fulfillment experience can be executed digitally. However, discontinuities in approaches to manage innovation falsify inside-out knowledge-based assumptions of firms related to research and development, and processes used for discovery of new opportunities. For example, the human genome project raises questions about the imminent liability of capital-intensive R&D labs in leading pharmaceutical companies (Christensen, 1997). Similarly, the open source movement points to the potential for peer-to-peer networking for innovation and underscores the potential of an outside-in approach, with a focus on customer needs (von Hippel, 2005).

### **3. VALUE CREATION ASSUMPTIONS IN SUPPLY CHAIN CONFIGURATIONS**

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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). Recent work on supply chain capabilities suggests that supply chains can be configured to differ substantially in their assumptions about the demands for knowledge creation and their organizing logic to create and exploit knowledge (Choi *et al.*, 2001). However, supply chains operate in dynamic

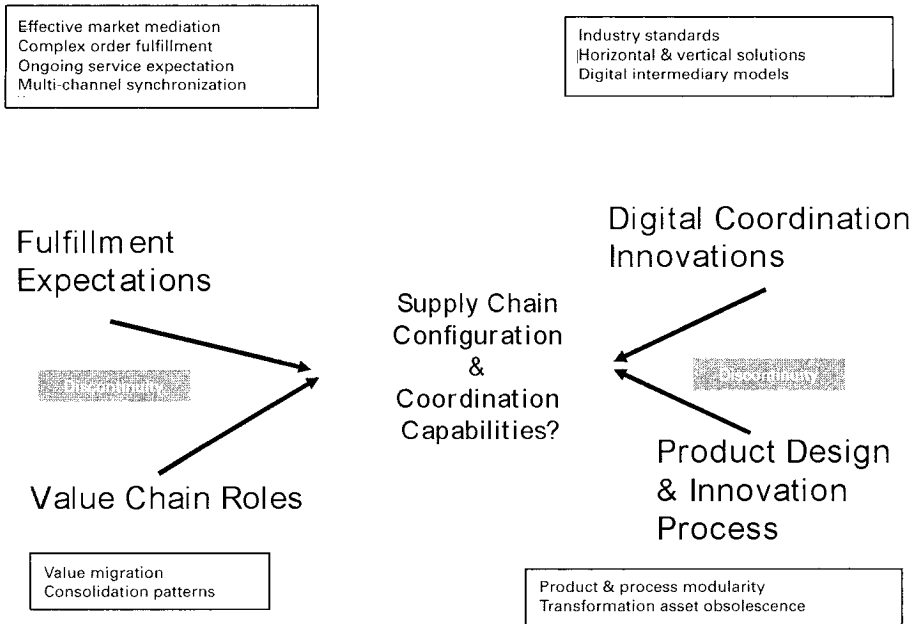


Figure 1: Supply Chain Transformation Drivers.

environments that require effective management of resources to adequately respond to changes in the environment. Firms must consider how they structure their overall portfolio of resources, bundle these resources to build capabilities, and leverage these capabilities to exploit market opportunities (Sirmon *et al.*, 2007).

To further develop this perspective, we identify and compare and contrast five supply chain configurations that differ in their value creation assumptions and the structure of their overall portfolio of resources. Figure 2 schematically contrasts these configurations in terms of their fulfillment perspective, ranging from product push to demand pull, and organizing logic, which can be oriented towards the firm, markets, hierarchies or networks.

Table 2 compares and contrasts the value creation perspective of the five supply chain configurations. Each of these supply chain configurations emerges from theoretical perspectives that define the locus of resource creation and utilization among firms. Vertically integrated and fragmented supply chain configurations follow a resource-based perspective where the focus of the firm is on achieving resource complementarity within the boundaries of the firm (Barney, 1991; 1995; 1999; Bharadwaj, 2000). End-to-end and modular supply chain configurations follow a dynamic resource capability perspective where the focus is on managing resources and achieving complementarities across firm boundaries (Dyer and Singh, 1998). Solution webs are motivated by a knowledge-based perspective where the focus is on dynamically integrating knowledge

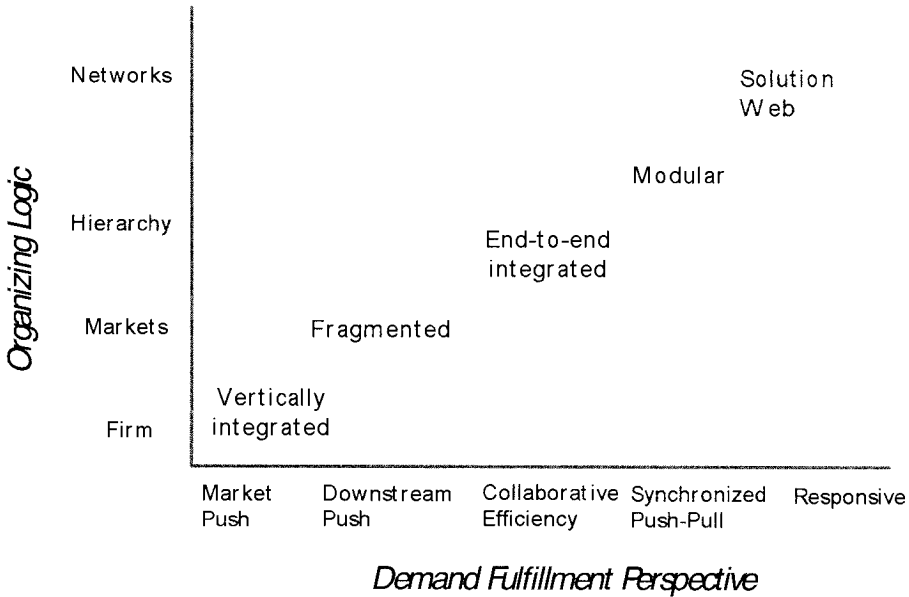


Figure 2: Supply Chain Configurations.

across firm boundaries (Grant, 1996). We now discuss each configuration's knowledge-based assumptions and value-creation perspective and then proceed to examine how they manage resources and coordinate their capabilities in the face of changing market opportunities.

### 3.1. Configuration #1: Vertical Integration

The enterprise is viewed as the competitive unit of analysis. This configuration emerges in stable environments where demand uncertainty is low and leveraging economies of scale is the primary objective. 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.

In this scenario, firms may diversify into related or unrelated initiatives to optimize use of resources or revenues (Dewan *et al.*, 1998; 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 complemen-

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 gaming in supply chain	Cooperation for efficiency	Mass customization and postponement of differentiation	Sense and respond to customer problem or need with a total solution
Integration of Product- & Process- Knowledge	Tightly coupled within the firm	Limited sharing with partners	Integrated supply chain plans & execution processes	Separation of modular & architectural knowledge.	Separation of modular, architectural and platform knowledge.
Locus of Resource Complementarity	Achieved within firm boundaries	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
Focus of External Coordination	Minimal	Non-core activities	Supply chain planning & execution	Product innovation; supply chain planning & execution	Dynamic knowledge integration for sense and respond capabilities
Relationship Specificity of Supply Chain Assets	Low	Low	For supply chain planning/execution	For innovation & supply chain planning/execution	For dynamic knowledge integration for sense and respond capabilities
Considerations for Contracting with Partners	Minimize transaction cost & risk of opportunism	Minimize transaction costs & risk of opportunism	Efficiency and predictable service levels	Innovation capability & predictable service levels	Complementary services and capabilities; problem-solving competencies

Table 2: Value Creation Perspectives and Role of Supply Chain Resources in Supply Chain Configurations.

tary product lines requires managing complex reciprocal interdependencies. For example 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. For example, 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.

### **3.2. Configuration #2: Fragmented Chains**

The channel is characterized by fragmented resource flows and processes among suppliers, manufacturers, distributors, and retail firms. This configuration emerges in highly fragmented environments where the cost of integration is high and conditions for cooperation are non-existent. Few central players exist. Instead the environment is

characterized by many small players. The firm primarily 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 and misaligned incentives 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 gaming strategies, such as massive price discounting, forward buying, diverting, and lack of information sharing, are used to aggressively compete with these upstream and downstream firms (Clemons and Row, 1993).

Fragmented supply chains contribute to error amplification of demand forecasts and supply chain inefficiencies. For instance, 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 & Gamble observed a similar problem in their diaper supply chain. These companies addressed supply chain inefficiencies by integrating information flows and establishing collaborative

practices, such as forecasting and capacity planning, across the supply chain.

### **3.3. Configuration #3: End-to-End Integration**

Competitive pressures make it infeasible for firms to remain economically viable by incurring high market mediation costs caused by inefficient operational execution. End-to-end integration emerges when stable demand conditions exist and the costs of coordinating supply chain activities among multiple players is prohibitively high. In competitive environments, poor fulfillment, which is caused by fragmented supply chain processes, takes a massive toll on revenues, customer acquisition and retention, and operating costs (Kamalini and Speakman, 2000). To address these challenges, under this configuration, an integrated supply chain perspective replaces an enterprise-centric mindset. In effect, the value creation focus shifts from local optimization of a firm's activities and resources to global optimization across multiple stages of the supply chain. To manage such optimization, process knowledge for collaboration among partners is generated and applied to improve planning and execution of activities. Wal-Mart successfully implemented a strategic, collaborative trading relationship with Proctor & Gamble that ultimately resulted in end-to-end integration; K-mart, in a similar relationship with Proctor & Gamble, achieved distribution efficiencies but stopped far short of fundamentally changing trading relationships and achieving end-to-end integration (Koch, 2002). These two

companies illustrate the contrast between pursuing an end-to-end integration strategy where operational inefficiencies in order management, fulfillment of goods and services, and revenue management are systematically addressed (Wal-Mart) versus a piecemeal approach (K-mart) that fails to have a positive impact on revenue.

### **3.4. Configuration #4: Modular Chains**

While integrated chains are designed to address inefficiencies caused by local optimization, they are not responsive to shifts in customer preferences. To address this limitation, modular design can be applied to products, processes and supply chain resources to enable integration of resources and capabilities among supply chain partners (Fixson, 2005; Richard and Devinney, 2005; Strader *et al.*, 1998). Modular chains emerge as a mechanism to be responsive and adaptive to shifts in customer preferences. Such modular chains can enhance supply-side alignment with unpredictable demand patterns. By definition, modular systems are characterized by loose coupling among subsystems and components. This low interdependency leads to high recombination enabling heterogeneous inputs to be recombined into heterogeneous configurations thereby increasing product variety (Schilling, 2000).

Additionally, modular chains can promote distributed innovation among supply chain partners (Matthew, 2000). When modular product designs are complemented with shared architectural

knowledge, suppliers can engage in modular innovation 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 increase product variety, postpone differentiation, and enhance alignment of offerings with customer requirements. Similarly, companies, such as UPS' Supply Chain Solutions group and SAP, now offer parameterized and modular software products that can be configured to meet client requirements. This modular product design approach enables a superior response to heterogeneous requirements by customers and better alignment of what is offered with their needs.

### **3.5. Configuration #5: Solution Webs**

While modular chains enable mass customization and responsiveness to customer preferences, they do not integrate the complementary services required for a complete solution to customer needs. Solution webs emerge when firms that operate in highly differentiated customer markets align their organization structure and technology to sense customer needs and to integrate capabilities and services across a network of business partners to respond to them. The importance of such a

dynamic capability to acquire and leverage resources has been recently theorized as a compelling basis for competitive advantage relative to a focus on the resources possessed by the firm (Sirmon *et al.*, 2007). Platforms provide the necessary business architecture to plug in business processes and capabilities from different vendors and firms, and to integrate their complementary competencies (Ciborra, 1996; Fichman, 2004). As providers of services, firms can enhance network externalities and experience increasing returns to scale by embedding their capabilities into multiple solution webs (Arthur, 1996).

Consider the following illustrations where companies have identified a demand and moved rapidly to establish complementary partnerships to fulfill this demand. Amazon.com has partnered with toy retailer Toys "R" Us whose foray into online retailing failed because of distribution problems. This partnership gave Amazon.com a foothold in the toy market and Toys "R" Us was able to leverage Amazon.com's superior logistics capabilities. In addition 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. Well-developed digital platforms enable these rapid connections among partners to leverage complementarities.

Companies across many different industries are shifting toward total solutions in their product offerings. Consider the automotive industry where car manufacturers offer in-vehicle systems

that provide a package of services designed to offer safety, security, and convenience (Rai and Sambamurthy, 2006). For example, General Motor's OnStar system offers services to locate lost vehicles, report an accident, run vehicle diagnostics, and provide turn-by-turn driving directions. The OnStar system meshes technology with telecommunications within the car.

In a similar vein, Apple has been successful offering total digital music solutions. Apple's agreements with the recording industry have allowed the company to offer individual digital songs to consumers. Their suite of iPod devices are designed to seamlessly integrate with iTunes software that runs on the user's computer. The iTunes software is necessary to access Apple's online store and purchase songs. The iTunes software provides a way for users to organize their songs and transfer them to iPod devices. Apple offers a total digital music solution that leverages the recording industry's ability to digitize music with Apple's ability to distribute and manage the digital content.

#### **4. DIGITAL COORDINATION FOR SUPPLY CHAIN CONFIGURATIONS**

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The underlying value creation assumptions identified in the previous section influence how digital coordination is achieved. Now, we discuss how digital coordination is achieved in each of the five supply chain configurations.

##### **4.1. Configuration #1: Vertical Integration**

In this configuration, operational coordination is focused on reducing operational risks and optimizing process efficiency, largely within the firm and to a limited extent across the value chain. In this scenario, product line diversification increases the need for internal coordination. The demands for such coordination are greater for related diversification, in comparison to unrelated diversification, due to the need to manage interdependencies across product lines.

For this configuration, 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 information resources are shared to enable a coherent, integrated organizational system (Cox and Blackstone, 1983). In general, these Advanced Manufacturing Technologies have been shown to improve a firm's production efficiency, while constraining market-responsiveness (Brandyberry *et al.*, 1999).

Digital coordination solutions for workflow, business process reengineering, intranets, and enterprise resource planning are illustrations of technology initiatives launched to streamline internal processes and information sharing practices. However, it is important to note that design decisions must be made to align the enabling IT with the organizational strategy. For instance, Hewlett-Packard maintained business unit autonomy in its ERP implementation, while Dow Chemicals implemented an integrated ERP solution to achieve resource sharing across complementary business lines (Davenport, 1998).

**4.2. Configuration #2: Fragmented Chains**

When firms operate in fragmented chains, resource optimization decisions are typically made within the boundaries of each enterprise. In this scenario, the incentive structures typically lead to limited investment in digital technologies for interorganizational coordination. Moreover, the information asymmetries and segmented inter-organizational systems constrain *substituting* information flows for physical stocks, such as inventory. Lack of sharing demand information, such as order-related data, causes the bullwhip effect, where minor variations in demand are amplified upstream in the supply chain (Lee *et al.*, 1997). Additionally, safety stock requirements are exaggerated at each stage in the upstream supply chain.

The above practices result in high market-mediation costs even for func-

tional products, such as diapers, that are characterized by relatively stable demand. These costs surface in the form of stockouts, stockpiles, inefficiencies of fixed and working capital, and poor customer service. Segmented inter-organizational systems constrain supply chain-wide management of yields, global customer accounts, and receivables and payables (Magretta, 1998). Given the nature of the business practices that characterize fragmented chains, digital coordination solutions, such as EDI and web-based EDI systems, are very often applied to automate existing patterns of information flows and to reinforce decision structures and roles.

**4.3. Configuration #3: End-to-End Integration**

*Sharing Information to Align Processes*

In this configuration, there is broad-scale sharing of private information among partners in the supply chain. For example, retailers share point-of-sales data with distributors and manufacturers so as to improve inventory management and reduce market mediation costs (Fisher, 1997). Similarly, distributors share information with manufacturers about retail orders, capacities and in rare occasions even cost structures. The manufacturers in turn, use this information for capacity planning and production scheduling. Such information sharing practices enables lean practices and a balanced flow of goods and services through the supply chain.

The shared information plays a crucial role in enabling processes, such as collaborative forecasting and replenishment and vendor-managed inventory, that can streamline delays and inventory buffers across the supply chain (Rai *et al.*, 2006). 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. In some cases, such as the 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, Procter & Gamble achieves steady flows through the system. However, it is important to note that sometimes while information is shared among parties, decision rights related to ordering and replenishment may not be transferred to partners (Simchi-Levi *et al.*, 2003). For example, Barilla, an Italian manufacturer faced significant challenges when it floated the VMI concept to its distributors. Its internal incentive systems and those of its distributors were significant impediments to the transfer of decision rights related to replenishment from the distributors to Barilla and consequently to the concept of vendor managed inventory.

### ***Leveraging Interdependent Flows***

Companies, such as Cisco and Li & Fung, have developed deep competencies to generate digital assets and to deploy them to optimize physical and revenue flows across massively dis-

tributed global operations (Margretta, 1998). Interestingly, these companies barely touch physical products. Instead, they manage processes to coordinate flows of information, knowledge, finance, and goods through their supply chains. By achieving visibility of production capacity, schedules and inventory holdings, the partners in the chain can make optimal decisions from a supply chain-wide perspective. Given the important role of visibility, third-party logistics providers are investing substantial resources to develop digital infrastructures and coordination solutions that complement traditional transportation and warehousing solutions (Lee and Whang, 2000; Margretta, 1998). Thus, firms can leverage their IT capabilities to establish higher-order process capabilities that integrate the flow of information, finances, and materials through the supply chain, and such a higher-order capability has been shown to have a substantial impact on firm performance (Rai *et al.*, 2006).

### ***Aligning Decision Structures and Network Design***

Developing supply chain-wide efficiencies requires a review of objectives, decision structures, network design, and resource sharing practices. 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, Saturn triggers shipment decisions 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.

### ***Aligning Multi-Channel Operations***

As bricks-and-mortar companies re-define how they manage their traditional and online businesses, they need to re-configure operational capabilities for multi-channel environments (Gulati and Garino, 2000). Consider the case of CVS and its online channel, CVS.com, which successfully integrated its online business with its existing stores. Their multi-channel business model is based on tight coordination of ordering and fulfillment operations between CVS.com and CVS' 4,100 stores across the United States. 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. Despite the obvious benefits of multi-channel integration, the grocery industry has been less successful in this area. The primary shortcoming of traditional brick and mortar retail grocers that take their business online is lack of integration

across channels. Similarly, some new entrants into the online grocery business have faced formidable challenges because of integration issues. For instance, Webvan, one of the early entrants into the online grocery business, was unable to integrate its delivery logistics with its order processing in a cost effective manner. As a result, they could not compete with the traditional retail grocery stores and eventually were forced to declare bankruptcy (Boyer and Hult, 2005).

In multi-channel operations, channel separation-integration decisions need to be complemented with pricing and discounting decisions. These considerations are especially important as differential pricing structures between online and offline channels can promote cannibalization and should be coordinated to generate the desired revenue from each channel operation (Gulati and Garino, 2000).

### ***Enabling Digital 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 while IT range determines application support for planning and execution of supply chains. In fact, the integration of applications and data supporting a range of supply chain capabilities have been identified as core foundational digital capabilities that enable higher-order process capabilities related to the

integration of resources across a supply chain (Rai *et al.*, 2006).

Dedicated solutions, such as EDI, have traditionally worked well in establishing connectivity and supporting information sharing between long-term, high transaction volume relationships. For example, EDI linkages between automobile manufacturers and their first-tier suppliers can lower shipping discrepancies, expedite payment recovery, reduce order processing errors, and cut down transportation, inventory and operating costs. However, the proprietary nature of EDI systems has made their implementation challenging for many firms. In contrast, 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 integrate with their trading partners.

Achieving visibility of operational activities related to orders, pick-pack-ship, returns, and service requests requires implementation of supply chain execution applications. Additionally, 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 applications can optimize coordination among distributed processes (Yang, 2000). For example, an online order can automatically trigger pick-

pack-ship, billing, and inventory updates. Supply chain planning applications possess sophisticated modeling capabilities, which when coupled with data from execution applications, can be used to align decisions related to procurement, production, inventory, transportation, and warehousing. In fact, some e-markets have included such planning and execution capabilities in their portfolio of value-added services.

#### **4.4. Configuration #4: Modular Chains**

##### ***Rationalizing Buffers for Components and Sub-Assemblies***

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). This is in contrast to end-to-end integrated chains for functional products, which are characterized by integral product designs, stable demand patterns and low innovation rates. As with end-to-end integrated chains, achieving visibility and leveraging information flows, planning collaboratively, scrutinizing design of decision structures and network design, and partnering with logistics providers are key practices for successful modular chains. Yet, there are critical considerations to be kept in mind to avoid a singular efficiency focus or over-emphasis on lean practices that is the case with end-to-end integrated chains.

Sometimes a lack of understanding of the relationship between product strategy and supply chain strategy leads companies that offer innovative products to over-emphasize lean practices. This misplaced emphasis can lead them to squeeze out critical buffers, creating an unresponsive supply chain. In such situations, brilliant product designs and business models are unable to mitigate problems with poor order fulfillment. E-tailers, such as Toys “R” Us, have faced criticism for their poor fulfillment, as has Compaq for its inability to fulfill massive demand for its popular iPAQ handheld device. Multi-echelon planning for buffers accounts for the inherent unpredictability of demand patterns and the importance of incorporating slack resources to hedge against uncertainty. Staging these buffers effectively throughout the supply chain can reduce the costs of flexibility. For example, inventory can be rationalized at the component and sub-assembly level, as opposed to finished goods, to reduce carrying costs and hedge against the demand uncertainties associated with specific product configurations.

### ***Moving Configuration Closer to the Point of Demand***

Modular chains balance the scale economies of push models with the customization capabilities of pull models (Simchi-Levi *et al.*, 2003). For example, since the introduction of the iPod in 2001, Apple has offered 72 different models of this product. Whenever demand for a particular model does not match projections, Apple is able to

quickly adapt its manufacturing process to meet the change in demand. In 2005, Apple introduced the Nano predicting that white would outsell black by a ratio of 8:1. When black Nanos quickly sold out and white Nanos remained on store shelves, Apple was able to adjust its manufacturing process to adapt to this unpredicted demand. Thus, while the production and distribution for components and subassemblies is driven by periodic forecasts, it is the actual order or a close proxy that triggers the assembly of specific configurations. To capture the value-creation opportunities offered in this push-pull supply chain configuration, distributors and logistics providers are offering assembly and after-sales repair services. To achieve the necessary coordination among partners, integrated processes are required to manage reciprocal interdependencies between production, assembly, transportation and distribution.

Manufacturers, such as Apple and Dell, use the digital and physical networks of third-party logistics providers to manage the assembly and distribution process. Leading third-party logistics (3PL) solutions providers have invested significant resources in their digital coordination capabilities and the market for 3PL providers has been expanding dramatically (Matthew, 2000). They have developed sophisticated coordination capabilities to stage components and subsystems from the supply to the demand side without pre-configuring stocks that are misaligned with the market. Consequently, some firms are using partnerships with logistics firms to increase inventory velocity

through assembly of final configurations in the distribution channel itself.

### ***Enabling Digital Solutions***

Modular chains need to be architected using modularized processes with well defined interfaces. Developments in partner interfaces protocols (PIPs) have established standards for common transactions, such as ordering, payments, automated shipment notification, in selected industries. For example, RosettaNet works to create industry-wide open standards for business processes. Within RosettaNet several different supply chain configurations have emerged that implement open standards in different ways. In collector supply chain partnerships, processes are highly modular, the adoption of standardized business interfaces is moderate, and a moderate amount of high quality information is exchanged. These types of configurations have been able to achieve higher levels of operational efficiency. Conversely, cruncher supply chain partnerships exhibit a low level of modular processes, a low adoption of standardized business processes, and share a low amount of moderate quality information. As a result, they achieve a low level of operational efficiency (Malhotra *et al.*, 2005). Additionally, the reciprocal interdependencies between modular processes that are distributed across partners can be managed through service-oriented architectures and web-based event driven architectures.

Open standards do not provide the complete set of solutions to coordinate the activities of modular chains. Quasi-

open standards that can be applied to a network of partners provide additional capabilities for the exchange of information and knowledge and for the coordination of resources, decisions, and activities. For instance, 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 (Lee, 2002).

### **4.5. Configuration #5: Solution Webs**

#### ***Orchestrating Complementary Services to Provide Total Solutions***

As the global economy becomes services-oriented, the focus of what is delivered to the marketplace is shifting from goods to services. In fact, complementary services are being configured and assembled to offer total solutions. To provide such total solutions,

peer-to-peer architectures are being designed to configure and orchestrate services in response to customer requirements. These webs focus on peer-to-peer collaboration among partners that cut across traditional business, industry and sector boundaries.

### ***Implementing Platform Architectures for Service Orchestration***

Digital platforms for solution webs must establish a standards-based architecture to support the collaboration and transaction among suppliers and customers. A service-oriented architecture is a possible solution as it relies on the concepts of loose coupling and modularity and encapsulates services with well-defined interfaces. Additionally, the orchestration of complementary services for a total solution relies on a rules-based architecture to coordinate peer-to-peer collaboration among providers of services and customers. In identifying opportunities for such encapsulation and disaggregation of services, information intensive activities where information flows and physical flows can be separated are especially well suited (Mithas and Whitaker, 2007).

Table 3 summarizes the digital coordination capabilities for the five supply chain configurations.

## **4.6. Transforming Supply Chain Configurations**

### ***Integrating the Demand-Supply Chain***

Successful e-business companies, such as Amazon, Dell Computers, Cisco Sys-

tems, and McKesson, have used digital 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 align supply- and demand-chains by integrating supply chain management, enterprise resource management, and customer relationship management. This requires infusing digital coordination technologies, such as Web-based applications delivery, distributed and real-time transaction processing, heterogeneous data management, and decision support technologies, into the planning and execution processes across the end-to-end supply chain. In addition, the multi-channel integration strategy should directly inform supply chain coordination requirements that align decisions, activities, and resources across channels.

From a coordination capability perspective, both the nature of information sharing and the allocation of decision right impact the alignment of supply chains. For example, information sharing without transfer of decision rights to vendors can potentially constrain the effectiveness of vendor management inventory. Moreover, achieving end-to-end alignment of processes requires scrutiny of goal incongruence and minimization of principal-agent conflicts. Developing and implementing incentive structures, long-term contracts, and

SUPPLY CHAIN CONFIGURATION					
PROPERTIES	Vertically Integrated	Fragmented	End-to-End Integrated	Modular Chains	Solution Webs
Fulfillment focus	Repeatable, predictable & efficient fulfillment of standardized products	Batched 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
Nature of Interdependencies	Pooled, sequential & reciprocal interdependencies within firm	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 internal value chain activities	Firm's internal value chain activities & transaction costs	Global optimization through planning & execution of supply chain processes	Synchronization of supply- and demand- facing processes	Knowledge integration across peers for sense and respond capabilities
Role of Logistics & Distribution	Integrated into internal portfolio of firm's activities	Third-party providers focus on breaking bulk & risk pooling of inventory	Capabilities for the continuous flow of information, revenue & goods	Assembly of final configurations based on order information	Sensing of customer requirements & integration of capabilities of peers for total solution
Nature of Information visibility	Internal information sharing	Dyadic transaction data	Information related to orders, fulfillment, & settlement	Interface specifications and configuration constraints: order, fulfillment & settlement	Customer requirements; descriptions of services offered by peers
Orientation of Information Systems Portfolio	Enterprise resource planning	Enterprise resource planning, EDI for transaction exchange	Supply chain planning & execution, enterprise resource planning	Supply chain planning & execution, enterprise resource planning, CRM	Digital platform for services integration (e.g., service-oriented architecture (SOA))
Process Standards	Proprietary standards for internal process integration	Market-based standards for transaction integration	Standards to streamline end-to-end supply chain processes of procure-to-pay with suppliers and order-to-cash with customers	Partner interface processes (PIPs) and industry-wide standards for process management (e.g., RosettaNet)	Standards for the transportation, requisition, response, registration, and description of services provided by peers

Table 3: Digital Coordination for Resource Management Processes in Supply Chain configurations.

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).

Given the above discussion, investments in digital coordination technologies must be complemented by information sharing practices, decision structures, and relationship management. Moreover, the design of processes and of the supply network should be evaluated to isolate constraints. Figure 3 summarizes the key areas to be addressed while transitioning to an end-to-end integration supply chain.

From a research standpoint, investigating the complementary capabilities required to infuse digital coordination capabilities into core supply-chain wide processes will inform our understanding of how integrated supply chains can be implemented. Moreover, investigating the pattern of effects between these complementary practices will provide a scientific basis to allocate managerial resources on maximally reinforcing practices.

### *Modularizing the Supply Chain*

Revenue models focused on standardized product offerings see a natural erosion of profit margins. While investments in digital coordination solutions enhance productivity and create consumer surpluses, IT does not seem to create sustainable profits, as supranormal returns are washed away through

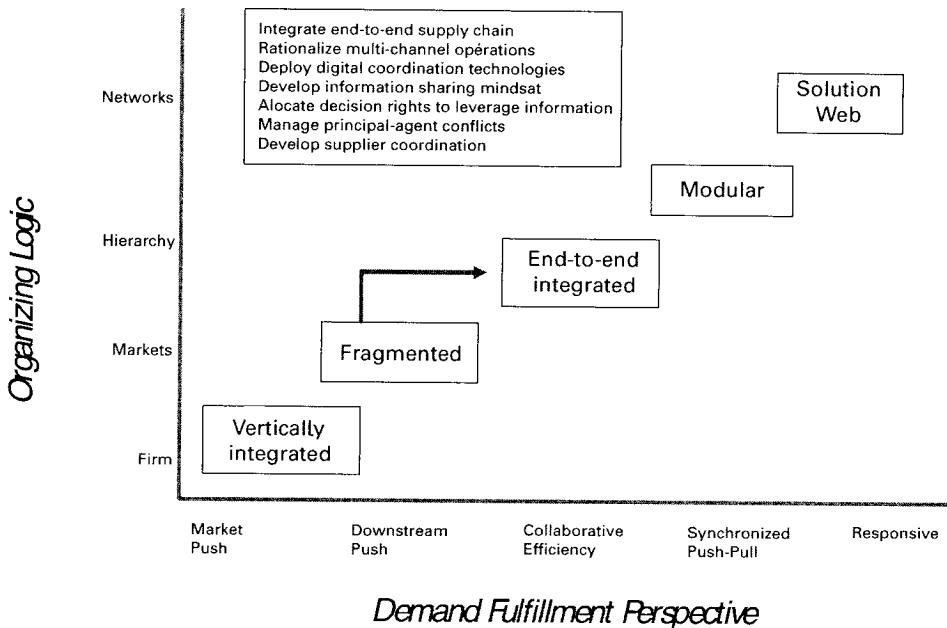


Figure 3: Transforming Fragmented Chains to Integrated Chains.

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 strategy to create value requires that the supply chain strategy be modified. In fact, it is a major error, and one often committed, to use an efficient supply chain strategy for innovative products (Fisher, 1997).

A shift in strategy from functional to innovative products requires transitioning from efficient to responsive supply chains. This transformation to responsive supply chain is not trivial and should not be underestimated. In fact, several companies have failed miserably or reported substantial hurdles in designing responsive supply chains due to inadequate emphasis on modularity (Fisher, 1997). These supply chains require a modular reconfiguration of products, processes, and enabling digital solutions. The modular architecture includes interface information to integrate processes deployed by specialized suppliers, contract manufactures, and distributors.

Importantly, the inherent demand uncertainty that characterize innovative products suggests that purely lean practices will be inadequate. Instead, it is crucial to develop buffers for components and sub-assemblies and establish processes and partnerships for their configuration into final products when order-related information is available.

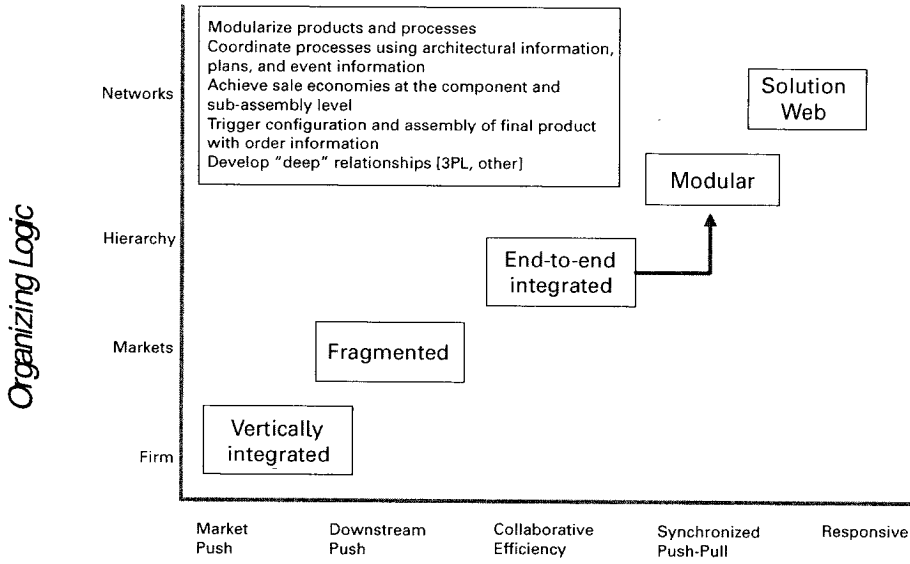
Figure 4 summarizes the key areas to be addressed while transitioning to a modular supply chain.

From a research standpoint, benchmarking the impacts of digital 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. Moreover, investigating the drivers of and patterns of assimilation of process standards in different contexts will provide an understanding of how and why specific standards are used. Finally, examining the effects of inter-firm process standards on the capabilities of firms to align processes and to adapt them in response to uncertainty will contribute to a broader understanding of the performance implications of such standardization initiatives.

### *Peer-to-Peer Networking for Total Solutions*

To respond to the solution requirements of customers, a flexible platform is required to collaborate with customers and to add or subtract complements offered by suppliers, existing and potential. This configuration must be enabled to manage an expanded cardinality of buyer-supplier interactions. If a well-defined architecture and business rules for the orchestration of the complementary services are not established, the scalability and revenue model of such networks is not sustainable. Figure 5 summarizes the key areas to be addressed while transitioning to solution webs.

From a research perspective, solution webs are an emerging area that continues to grow in importance as we transi-



*Demand Fulfillment Perspective*

Figure 4: Transforming Integrated Chains to Modular Chains.

tion to a services economy. What measures of service quality are appropriate for such peer-to-peer networks and how do these measures generate meaningful feedback? Rai and Sambamurthy (2006) raise a number of questions about the emerging services focus: How do firms determine appropriate boundaries when services are modularized and interfaces standardized? How can services be designed and managed for customer-facing processes in multi-channel environments? What governance mechanisms emerge when services are outsourced?

**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 providers of service to customers (Wise and Baumgartner, 1999). As the points of contact for service provisioning are close to customers, distributors have expanded their traditional roles to 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. There are similar movements in the IT industry with IBM Global Services providing Web services. By pursuing aggressive partnerships with IT solutions providers and financiers, traditional freight-forwarders are providing configured or customized fulfillment solutions. Fritz (now part of UPS Supply Chain Solu-

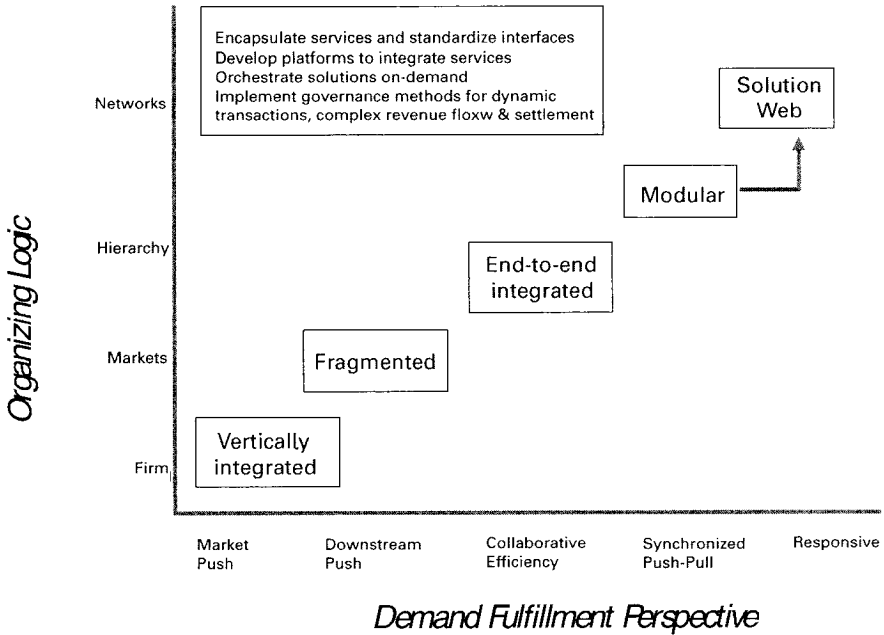


Figure 5: Transforming Modular Chains to Solution Webs.

tions) manages the global inbound logistics process for Apple Computers by creating specialized assets that enable it to provide high service levels (Lee and Whang, 2000). By assuming such service roles, logistics firms are competing with distributors and aggregators. Thus, it is critical that firms understand the emerging patterns of how value is created and appropriated within their industries and make necessary adjustments to their offerings and supply chain strategies.

**Responding to Consolidation Patterns**

There appears to be a natural pattern of structural evolution of industries (Fine, 1998). Vertically integrated firms that focus on efficiency are transformed to horizontal firms that focus on collab-

orative 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. In these scenarios, 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 impacts how value is created and distributed across supply chains and the role of intermediaries, including e-markets (Soh *et al.*, 2006). Intermediaries in such situations need to reevaluate their roles and develop

responses, such as providing value-added services, or disaggregating their business model and embedding them into multiple solution webs. The nature of digital intermediation under different conditions of buyer- and seller-consolidation, industry maturity, and stage in the supply chain are interesting research questions.

## **5. CONCLUSION**

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Our identification of the different supply chain configurations extends the theoretical perspective of dynamic resource management for firms by focusing on their role in supply chains. Specifically, our analysis of the supply chain configurations shows that the capabilities of firms to balance demand and supply can be a source of competitive advantage. In general, fragmented chains result in significant market mediation costs even when the final demand is predictable and are highly unresponsive to changes in demand and supply. Developing capabilities to effectively balance demand and supply requires that firms understand the underlying demand and supply characteristics of the product-markets that they operate in. Moreover, they must align their product strategy and supply chain strategy, and establish digital coordination capabilities to interface with supply chain partners. Such interfacing provides the digital capabilities to structure, bundle, and leverage the complementary resources and capabilities across the supply chain. In dynamic contexts, the modular design of products and processes and standards

for process integration provides capabilities to adjust what resources and capabilities are acquired and how and when these resources and capabilities are deployed.

The nature of environmental contingencies should inform the selection of the supply chain configuration that is designed and deployed. While the fragmented configuration may be sustainable in the short-run, the dynamics of the marketplace and the growth in the capabilities of supply chain solutions require that some form of integration with supply chain partners be evaluated and practiced. The nature of the product that is offered by a firm to customers and the design of the products and processes are major considerations in the configuration that is pursued. For firms operating in functional product markets, an end-to-end integration configuration is appropriate. Consistent with the assumptions of a neoclassical economics perspective, this configuration enables firms to globally optimize the utilization of factors of production and distribution. For firms operating in innovative product markets, a modular configuration is suitable. Finally, for firms that are offering total solutions to customers, a peer-to-peer networking architecture is required. These latter two configurations focus on responsiveness and innovation and not on achieving a global optimum under a given set of conditions. Rather, consistent with a Schumpeterian economics perspective, the organizing logic of these configurations is focused on change, adaptation, and innovation. Given the distinct assumptions and objectives of each of these con-

figurations, the role of supply chain resources differ substantially, as do their resource management processes and the digital capabilities that enable these processes.

As the environment becomes increasingly dynamic, it becomes important to shift the frame of thinking from the deployment of digital solutions to support a given inter-firm relationship to a solution to support the dynamic management of a *portfolio* of inter-firm relationships. Thus, a focus on integration with a narrow set of present-day partners does not provide for the required flexibility to redefine processes with these existing partners or to engage new partners. Towards this end, quasi-open standards, such as RosettaNet in the electronics industry and HL7 in the healthcare industry, that establish modular process interfaces can be particularly useful to enable dynamic partnering.

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.

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Achévé d'imprimer sur les presses de l'Imprimerie BARNÉOUD

B.P. 44 - 53960 BONCHAMP-LÈS-LAVAL

Dépôt légal : août 2007 - N° d'imprimeur : 707099

Imprimé en France