European Supply Chain Study

by

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"Setting an example is not the main means of influencing others, it is the only means."

Albert Einstein

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I dedicate this thesis to my wife Anu for her love and inspiration.

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To Anu

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Chapter 1: Introduction

1.1 Supply Chain Defined

Supply chain management has been defined as,

[68] *"..a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations and at the right time, in order to minimize system-wide costs.... satisfying service level requirements.."*

[52] *".. integration of activities ..through improved supply chain relationships to achieve sustainable competitive advantage.."*

[86] *"..coordination and collaboration with channel partners.. coordination of process and activities.."*

[53] *"..from the ore mine to the trash can...the production and distribution network that encompasses the sourcing, manufacturing, transportation, commercialization, distribution, consumption, and disposal of goods.."*

[4] *"...flow of requirement information from buyer to seller which triggers all later activities, the movement of goods from sellers to buyers, transfer of ownership rights from seller to buyer and payment from buyer to seller."*

The above definitions offer a broad spectrum of supply chain orientation and management choices available to companies. They could vary from a transactional orientation that is focused on low cost acquisition; to one where stronger relationships are established with key suppliers and customers in an effort to optimize and capture synergies; onward to a partnership orientation that is focused on supporting mutual goals for a sustainable competitive advantage. Making the right choice is essential. It can have a

significant impact on a company's balance sheet (Figure 1.1) and income statement (Figure 1.2).

	Inventory	Account Receivables	Account Payables	Fixed Asset	Total Assets
Perfect Order Fulfillment		●			
Order Fulfillment Cycle Time		●			
Upside Supply Chain Flexibility	●				
Downside Supply Chain Adaptability	●				
Upside Supply Chain Adaptability	●				
Cash to cash cycle time	●	●	●		●
Return on Supply Chain fixed Assets	●	●	●	●	
Return on working Capital	●	●	●	●	

Figure 1.1: Supply chain impact on Balance Sheet [79]

	Revenue	Cost of Good sold	Selling, General Adm. Expenses
Perfect Order Fulfillment	●		
Order Fulfillment Cycle Time	●		
Upside Supply Chain Flexibility	●	●	●
Downside Supply Chain Adaptability	●	●	●
Upside Supply Chain Adaptability	●	●	●
Cost of goods sold		●	
Supply Chain Management cost		●	●
Return on Working Capital		●	●

Figure 1.2: Supply chain impact on Income Statement [79]

GSCF and SCOR are two popular process frameworks in supply chain management [36]. Corporate strategy is the starting point of the GSCF framework, with the operational aspects of customer relationship management and supplier relationship

management linked to the strategy. Its process metrics are related to EVA. On the other hand, the SCOR framework focuses on transactional efficiency by integrating operational activities such as purchasing, operations, and logistics. It benchmarks process metrics to improve operational efficiency. A comparison of the GSCF and SCOR frameworks is shown in Figure1.3.

Criteria		GSCF	SCOR
Scope	Strategic Driver	Corporate and functional strategies	Operations strategy
	Breath of Activities	All activities related to the successful implementation of the 8 business processes	All transactional activities related to demand-supply planning, sourcing, production, distribution and reverse logistics
Intra-company Connectedness		Organization-wide cross-functional integration	Cross-functional interaction and information sharing
Inter-company Connectedness		Relationship management	Transactional efficiency
Drivers of Value Generation		Economic Value Added	Cost reduction and asset utilization

Figure 1.3: Comparison of GSCF and SCOR [36]

1.2 Current State

According to a recent global study [14] there are significant differences in how companies organize the management of supply chains. For instance,

- Logistiscs, transporation and warehousing functions were found in the supply chain organizations of 83% of companies surveyed.
- Purchasing, sourcing, inventory management, forecasting, planning and scheduling functions were found in the supply chain organizations of 70% of companies.
- Manufacturing function was found in the supply chain organizations of 34% of companies.

The costs allocated to supply chain reflected a similar trend, though the supply chain spend as a % of revenue was varied with 41% of companies spending as much as 30 %– 50% of

their revenue on supply chain costs. These organization and spend statistics reinforce the fact that supply chain continues to be a significant business activity in the current state, albeit with differences that could be attributed to the industry, geography and business strategy of a specific company.

The dynamic nature of supply chains requires that managers adapt [40] their supply chain strategies and operations in order to remain competitive. Typical adaptation objectives could include a more timely response to market changes or better alignment of partner incentives. Approaches such as lean manufacturing, just-in-time inventories, network optimization, integration of processes and systems, outsourcing and third party logistics networks are a few of the major adaptations we have seen in supply chains, during the past few decades. Every adaptation brought companies one step closer towards building integrated and globally optimized supply chains, which in turn has improved their overall business performance, measured by inventory turns, service level and total landed cost. Some of the popular strategies used in supply chain management could be categorized [2] as follows:

- pure standardization of products with a push strategy
- segmented standardization with a basic design modified for different customer segments using Kanban at the finished goods level, for shorter time-to-market
- mass customization of products using manufacturing and logistics postponement, by delaying assembly of modules until demand uncertainty is resolved
- mass customization by processing from a portfolio of designs
- pure customization from design to delivery, seen in large scale engineering projects.

1.3 Future Challenges and Opportunities

Fluctuations in transportation costs, an increase in the demand for products and services in emerging economies, the growing concern over climate change and geo political tensions present a new set of challenges and opportunities for supply chain management. It can be argued that another adaptation in global supply chains is a real possibility if

companies are to improve, or even maintain, the gains in business performance that were brought about by current supply chain approaches and strategies. These new realities will require managers to reconsider the existing trade-off decisions that were made to lower operating costs and grow margins. They could also necessitate even further collaboration and integration in processes and systems for better visibility and response. While the underlying principles of current supply chain management approaches and strategies will still hold true, the optimal set of solutions for a company's future supply chain is not completely obvious or intuitive.

Chapter 2: Project Description and Approach

2.1 Project Objective

The objectives of this 'European Supply Chain Study' project are as follows:

- identify the key trends, challenges and opportunities for European supply chains
- describe the differences and similarities between European and US supply chain trends and
- discuss the key supply chain management process changes and IT initiatives that could enable European supply chains to make the most of future opportunities

2.2 Project Sponsor

TrueEconomy (TE) is a Europe based firm that is a leader in the area of supply chain management consulting. It has successfully maintained double digit growth over the years by offering a broad range of services (Figure 2.1) to its European client base. These services are based on the client's requirement and vary from a single study or advice on a supply chain problem to a complete turnkey supply chain process and system implementation. Central to TE's growth strategy is its commitment to collecting ideas from leading business people, academics and professionals in various fields across discipline boundaries and sharing them with partners and clients. TE's sponsorship of this study is driven by that commitment to leverage our collective knowledge for improving supply chain performance [90].

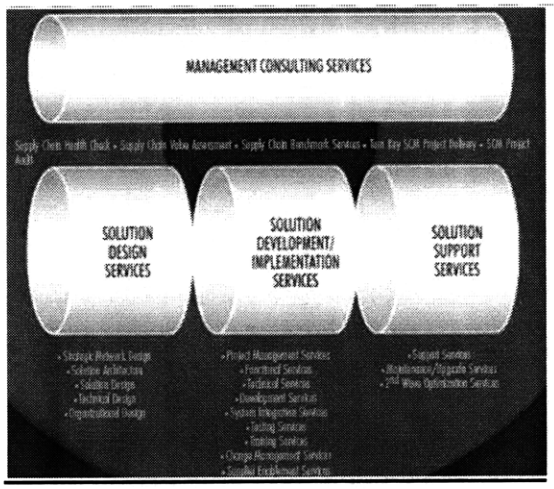

Figure 2.1: Services offered by TruEconomy [90]

2.3 Project Methodology

The methodology employed for this project is as follows:

Step 1

Complete a supply chain literature review by using the internet and leading supply chain journals, in order to:

- create a list of study focus areas
- describe concepts, strategies and trends reported by academia and industry in the study focus areas

Step 2

Complete a pilot study with 10 supply chain managers to verify the relevance and importance of the study focus areas (from Step 1), and establish a study scope for further investigation.

Step 3

Plan an empirical study with approximately 75 supply chain managers across Europe and US, to learn firsthand about the key trends, challenges and opportunities they see. The

managers who would participate in the empirical study represent TE's client companies in Europe and US-based companies who are members of MIT's Forum for Supply Chain Innovation.

Step 4

Develop and administer a survey to complete the empirical study described in Step 3.

Step 5

Analyze the survey responses to fulfill project objectives.

Chapter 3: Literature Review

Please also refer to Appendix A1 (page 78) and Appendix A2 (page 83) for additional details regarding the literature review.

3.1 Supply Chain Objectives and Metrics

Supply chain objectives and metrics typically emphasize improving and measuring the performance of an end to end business process. Precision, robustness and disciplined use are therefore key considerations, as is creating a measurement friendly culture through personal role modeling [31]. Objectives and metrics could be thought of in three dimensions [29, Griffis 2004]:

- Competitive basis: This dimension has responsiveness and efficiency as its anchors. It is largely based on Professor Fisher's work [20] that products with predictable and stable demand are best supported by an efficient production system, while innovative products with unstable demand are best supported by a responsive production system.
- Measurement focus: This dimension has strategic focus and operational focus as its anchors. It is found in the SCOR framework, where Level I metrics measure the relative position and success of a company and Level 2 and 3 metrics focus on a narrower subset of processes.
- Measurement frequency: This dimension has diagnostics and monitoring as its anchors. It recognizes that some measures need to be monitored on a day-to-day basis where as others are to be consulted infrequently for an ad hoc analysis of known problems [Bowersox & Droge 1989, Lancioni & Gattoma 1992].

Supply chain objectives and metrics have also been targeted more specifically on simultaneously improving service level and working capital utilization. In the case of Staples [5] a large US based retailer of office products, the portfolio approach for allocating resources based on a merchandising category's role and intent was successfully

used to achieve service level and working capital objectives. Gains came from faster turns, less obsolescence, faster cash flow, and greater market share, all contributing to inventory efficiency and gross margin expansion. Alignment of objectives is equally important to minimize hidden actions by partner companies; hidden information-data or knowledge that only some of the companies in the supply chain possess [60]. In a separate case, having the manufacturing schedule based on actual consumer demand, resulted in an improved understanding of the true costs required to support the demand. This brings up the need to redesign supply chain incentives by changing how, rather than how much, a company pays its supply chain partners to improve supply chain performance. It moves beyond cost containment to innovation and value creation. Such a redesign also builds trust when risks are considered in the development of shared metrics with increased clarity around incentives and penalties.

Well developed supply chain objectives and metrics have the potential to drive significant, measurable benefits in the form of reduced working-capital investment, faster inventory turns, lower fixed costs, and greater return on assets while minimizing cross-functional conflicts.

3.2 Supply Chain Configuration

Supply chain configuration [20] is the set of choice made at each stage of the manufacturing and distribution network to meet the supply chain objectives. For example, the location, number and capacity of warehouses and factories; the sourcing, production and transportation flows; and the flow of information. Managing supply chain activities dispersed over evolving manufacturing and distribution networks requires a change in mind-set from a static supply chain configuration to one that is periodically evaluated for its appropriateness at a product, customer or even individual order level [25]. As Victor Fung, CEO of Fung Li aptly said "...think of our divisions as a portfolio we can create and collapse, almost at will." Focus on this dynamic nature of supply chains has also been described as being essential for maintaining a sustainable competitive advantage [40], as follows:

- Supply chain agility: The ability to react quickly to changes in demand or supply. This is achieved through collaborative relationships with suppliers and customers for promoting a smooth flow of materials and information; design for postponement to support inventory buffers of inexpensive but key components; and development of contingency plans.
- Supply chain adaptability: The ability to adapt over time as market structures and strategies evolve. This is achieved by modifying the engineering, manufacturing and distribution networks as new supply bases and markets become available; using third parties logistics infrastructure; creating flexible product designs' and continuously evaluating the technology and product life cycles.
- Supply chain alignment: The alignment of interests of all the companies in the supply network so that companies optimize the chain's performance when they maximize their interests. This is achieved by creating incentives for better performance; exchanging information and knowledge freely upstream and downstream; clear assignment of roles and responsibilities; and equitable sharing of risks, costs, and gains.

In short,beyond what customers currently value; supply chain managers have to identify the changes in what customers value and co-innovate for mutual benefit [21].

Manufacturing: [81] Domestically, raw materials imports into the western part of the European Union could begin to shift towards new manufacturing bases in the eastern part of the European Union. On an industry specific basis, it was found that [64],

- The European chemical industry is particularly vulnerable to Asian manufacturers, from commoditzation brought about by the expiry of patents; the widespread propagation of manufacturing knowhow; and the increase in price transparency. For improving business performance, reducing supply chain costs and improving working capital utlization are the top two levers being considered by the supply chain managers in this industry.
- Manufacturers in the pharmaceutical industry continue to have poor performance and low supply chain maturity.While the exipry of patents has led to price erosion

by low-price generic products, in order to maintain profitability manufacturers are being driven to consider more outsourcing of manufacturing and mergers.

- Asian markets are becoming even more important for survival of manufacturers of lighting and machine tools. However, reducing costs to take advantge of these markets will necessitate cross border integration and outsourcing .
- Restructuring their operations to become more solution-oriented through closer integration with hospitals is on the rise among medical equipment manufacturers, to address rising patient care costs. However these manufacturers are still struggling with internal integration of their supply chains.
- Achieving supply chain efficiencies may also trigger an increase the increase in level of mergers among telecom and communications equipment manufacturers.

Distribution: [81] Benelux region has traditionally attracted a number of European Distribution Centers (EDCs). Table 3.1 shows the attractiveness of locations for EDCs. The Europe DC location decision is influenced by:

- the transportation infrastructure within the country
- labor costs
- proximity to major global ports and rail hubs
- proximity to customers, suppliers
- real estate costs
- incentives and corporate taxes
- language
- congestion risk and utility infrastructure.

Best-in-class*	Second best*	Middle*	Last-in-line*
Belgium	Bulgaria	Estonia	Austria
Germany	Czech Republic	Finland	Cyprus
Netherlands	Denmark	Italy	Greece
	France	Latvia	Malta
	Hungary	Lithuania	Portugal
	Ireland	Slovakia	Romania
	Luxembourg	Spain	Slovenia
	Poland		Sweden
	United Kingdom		Turkey

*Countries are listed in alphabetic order

Table 3.1: Attractiveness of locations for European DCs [18]

With Germany having both well developed road and rail transport infrastructures, a rise in multi-modal transport infrastructures is expected on the borders of Germany. Furthermore, while the Dutch rail investment project effectively improves the strong position of the port of Rotterdam, it supports the movement of EDC locations towards Germany. The earlier decision to locate EDC's with value added operations in Netherlands might be reconsidered, as road transport is replaced partly by rail transport, and the access to Poland, Slovakia and Bulgaria now provides high availability of labor. Bulgaria also scores high on proximity to seaports [18]. Within Europe, differences in distribution also reflect variations in accessibility. For example, Italian companies generally opt for highly local, depot-type distribution networks, while companies in Netherlands prefer a centralized approach. It is expected that the congested road systems around Europe's major metropolitan areas could also bring about changes. Regional distribution models have evolved from different countries' ability to use their road networks. [18] For instance, a major European utility replaced 55 manned secondary warehouses with 150 unmanned pick-up points that field crews go directly to and pick up needed materials outside normal working hours. Within the now enlarged EU, a faster adoption of alternative forms of transport combined with various depot structures to manage distribution is now a likely scenario.

[18] As different regions specialize in different areas, for example "Silicon Glen" in Scotland, the aerospace corridor around Toulouse, and the automotive cluster in Spain, it will also be vital to coordinate the development of these dispersed supply and

distribution networks with some level of redundancy in terms of physical assets. The possibility of an increase in bulk transports over Danube also could place Hungary in a strong position to win DC investments. On the other hand, Latvia and Finland could be attractive locations for export to the Russian market. A new import route through Russia is also a likely alternative for importing products from Asia Pacific to the European Union in lieu of sea transport West European ports.

The rise in DC reorganization could also trigger a wave of implementations of new warehouse management systems. Such implementations would provide the following benefits in the management of European DCs [55]:

- standardized processes that utilize best practices
- a focus on end-to-end execution capability through integration with transportation management systems and supply chain planning
- deeper optimization functionality for slotting optimization and resource management to leverage physical assets such as high land and labor costs
- flexibility and scalability in operations from configurable workflows for business process fit
- multilingual implementations for multi-country deployments
- duty and customs capabilities
- RFID support

Transportation: [7] To improve focus on core competencies, outsourcing of transportation and warehousing to logistics service providers is becoming common. Logistics service providers improve supply chain efficiencies by implementing flow-through strategies such as cross-docking or merge-in-transit. To the extent that transportation and warehousing costs are a significant cost for manufacturers and are critical to their operations, such outsourcing weakens their buying power [16]. This is because switching costs are high from a potential disruption of the distribution chain and reverting to in-house distribution has significant costs such as sourcing and staffing a new transportation fleet. [39] A difference between the US and European companies was that

US companies were more likely to address in the contract the process for termination and renewal of service beyond the initial term. In an analysis of in-sourcing v. outsourcing, some of the factors to be considered are:

- enhanced business processes
- improved capacity during peak seasons
- creating a positive experience during order entry and order fulfillment
- reduced stock outs
- improved product lifecycle management and
- navigating governmental regulations – particularly relevant in China.

[39] In Europe, companies that currently do not outsource logistics, nearly half are contemplating outsourcing at least part of their operation in the future. Majority of respondents who do outsource, report cost savings of an average 13% after outsourcing from inventory management, customer order management, customer service and supplier order management. While warehouse and transportation management systems are the technologies most commonly provided by logistics service providers, their IT capabilities remain a major issue for companies. Fewer report logistics effectiveness in Europe, possibly reflecting difference in how it is being approached. European companies are more likely to outsource transportation management whereas US companies are more likely to also outsource freight bill auditing and payment. Also, companies in Europe tend to spend more of their logistics budgets on outsourcing than their US counterparts. Future avenues of collaboration with logistics service providers could include the Sales and Operations Planning (S&OP) process in an effort to allow the service providers to better manage the network shared capacity and transportation and labor capacity.

Sourcing: [7] Global sourcing is on the rise at growth rates of over 20 percent. However, price is no longer an order winner but an order qualifier and negotiated prices are not as significant in supplier selection as is the willingness of the supplier to help achieve shared objectives [34]. These include ability to meet due dates, flexible contract terms and reserve capacity for unexpected demand. This is important because while a long term

fixed commitment to the supplier could reduce price risk it does not reduce inventory risk if the order quantities cannot be adjusted based on actual demand [44]. Option contracts are an alternative, wherein a small reservation fee is charged by the supplier to allow capacity reservation up to a certain level. The total price is therefore higher as it includes the reserve price plus exercise price, but it lowers risk. The authors [44] report that while flexible contracts, where both quantity and price can be changed are therefore better than the above two, a portflio contract approach that combines all three for increasing expected profit by taking into account the spot market is better for both the buyer and the supplier. From the buyer's perspective, the supplier who can serve many customers handles demand uncertainty by pooling. While the supplier's perspective could be that long term contracts have lower margins with certainty around revenue and option contracts have higher margin but uncertainty around revenue, a well designed portfolio contract addresses these issues.

[39] On the sourcing side, third party logistics service providers can also be relied upon to meter offshore supplies into manufacturing plants; consolidation of materials from multiple suppliers at regional hubs; train and manage suppliers. The scope of a 3PLs services could include optimizing total landed cost by considering regional tarriffs; safety stocks; and operational risk by onsite representation.

Customers: [7] On-time delivery and inability to fulfill customer orders due to out-of-stock continue to be challenges in meeting customer responsiveness and satisfaction targets. While, attainment of perfect customer order delivery to original request date is growing rapidly, it was found that supplier lead times are somewhat static. Fulfilling customer demand in emerging markets could therefore require a review of past supply chain segmentation strategies- the concept that "one supply chain does not fit all customer markets". Traditionally, supply chain segmentation has been influenced by the following factors [41]:

- product life cycle- supply chains of perishable products are supported by lower levels of inventory and fast transportation modes

- market- supply chains of high demand variability products are very responsive
- source, infrastructure or legislation constraints that require that the supply chain include specific locations

Figure 3.1 shows an example of an innovative segmentation strategy used by Sony BPE [41]. It was based on Product Value Density (PVD). The main benefits of such a strategy were overall cost reduction of 25%, increased sales by 100 % and improved service levels. High PVD products with the low chargeable weight were consolidated to a single global stockholding location and air freighted to customers (cell A). High PVD products with high chargeable weight and throughput were pooled into single regional distribution hub, replenished by air freight (cell B). Low PVD products with high chargeable weight and throughput were stocked at multiple distribution hubs, replenished by sea freight (cell C).

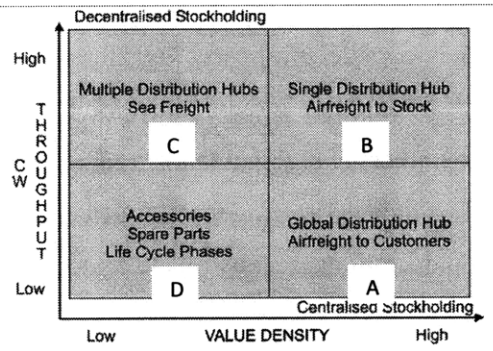

Figure 3.1: Stockholding strategy [41]

3.3 Risk

Figure 3.2 shows the SCOR perspective on supply chain risks in the suppliers' environment, customers' environment and internally within the company [79]. A failure mode analysis [79] could be undertaken by supply chain managers to score each of these major sources of risk and then prioritize the key ones to focus on. The scoring would require estimating the severity or impact of the risk; the probability of its occurrence; and the ability to detect it. For instance, one of the severities or impact of the risk could be a

permanent decrease in market share for the current product as well as reducing sales for other products, due to a consistent inability to meet customer needs. The supply chain manager may therefore decide to maintain higher safety stock and reduce the responsiveness utilization to changes in customer demand. Another mitigation strategy is postponement [Lee & Tang 1997, Lee & Padmanabhan 1998]. Postponement is an opportunity to learn from environmental factors and coordinate the deployment of inventory with key customers and suppliers, supported by a redesign of products and processes as follows:

- Standardization- common components or processes so that they can be used in multiple finished products.
- Modular design- delayed assembly of sub-modules into products
- Process restructuring- re-sequencing of some manufacturing steps to delay the assembly of the product-specific components.

Figure 3.2: Supply chain risk perspectives [79]

In addition to building in flexibility and redundancy, Figure 3.3 shows that it is equally important to react and recover from a disruption [66]. This is because in the wake of a disruption while performance can drop quickly, recovery is slow. Accelerating the recovery requires both a right cultural mindset and a clear set of priorities for the post-disruption period. Specfically for the customer facing processes there should be a clear understanding of which customers are to be served first based on the vulnerability of their operations or profitability to the company. Moreover such priorites should be seen as fair to avoid long term damage to customer or supplier relationships. For loyalty in supplier/customer relationships [48] it is essential that there be a similar understanding about the important elements of logistics service. It has been found that loyalty is driven primarily by factors such as handling problems and communication, which are relational, rather than fill rates and on-time delivery which are operational. Order splitting [80] is another interim tactic to respond to extreme conditions that could include exceptionally high lead-time volatility; relatively high demand rates; and relatively low incremental transportation and ordering costs. In such cases, the companies can chose to split a single order into smaller shipments. These shipments would be released sequentially in response to the demand conditions by different modes of transportation. So by carefully selecting a combination of different modes, a company may not only get service benefits from reliability but also cost benefits from a multimodal strategy.

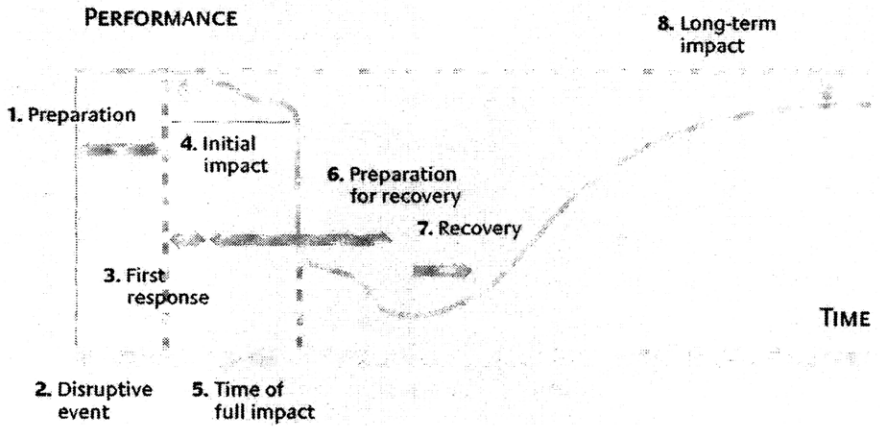

Figure 3.3: Performance as a function of time [66]

Another example would be if a company is replenishing many stores from one DC then it might split the loads and route two delivery vehicles in reverse order to these stores. FEDEX and UPS have systems that can warn of abnormally large delays, event alerts from such systems could be used by companies to strengthen their internal controls systems for recognizing a potential disruption and initiating a quick recovery.

Also RFID could warn and allow rerouting. To comply with the EU security legislation in Europe [79], some of the technologies that could grow in importance are,

- advanced and high speed data analysis for ensuring container integrity, such as e-seals, RFID and smart containers
- improved tracking and tracing techniques for supervision and monitoring maritime and air container
- improved detection and radiation equipment
- IT systems for the application of harmonized risk criteria to enable customs to exchange risk-related information by electronic means and focus on high risk consignments due to availability of risk-information at early stage

A recent study [51] of more than 200 global companies found that more than 60% supply chain managers agreed that supply chain risk has increased and less than 10% believe that it has decreased. Surprisingly only 10% of managers said that they are extremely capable in mitigating risk. These managers were also were twice as likley to do detailed cash flow analysis tailored to specfic risks..The major areas of risk in the most recent strategic operational cycle were said to be the labor cost, regulatory compliance, suppplier reliability, commodity shortages, exchange rate fluctuations and intellectual property theft. To minimize financial exposure to risks, companies reported the use of approaches such as performance contracts with suppliers, contingent suppliers; and passing through a price increase to customers. Even then, only 20% said that corporate standards and practices for overseeing the mitigation of supply chain risk were very well enforced. Consider the example, of products that last 10 to 15 years but use components that are available in the market for only 2-3 years after which they're discontinued [40].In this example, the ability of supply chain mangers to synchronize the changes both within its

own manufacturing and distribution network with those in the supplier and customer facing processes is essential for risk mitigation. This ability could be enhanced by scenario planning, where their contracting group can embed the risk-mitigation for the alternative scenarios into the contract.

3.4 Sustainability

[53] In a study of Landliebe Yogurt, made and sold in Stuttgart, Germany, it was shown that the ingredients: cultures, milk, strawberries, wheat, label, jar, and the lid, had traveled a total of more than 5,500 miles before consumption. This 1993 study was atypical as historically, the sustainability objectives have been limited to pollution control [35]. The typical approach of capturing harmful products during or at the end of the process left the product and its supply chain largely unaltered. For example, [35] Xerox's Asset Recycle Management Program successfully diverts 90 percent of all materials and components for its end of life photocopiers through reuse, remanufacturing and recycle, saving $300-$400 million annually. Figure 3.4 shows such a typical reverse logistics flow. Recycling involves collection, sorting, decontamination and disassembly to return materials to a commodity state where the identity of the original product is lost. Remanufacturing involves disassembly; replacement and reassembly to return the product function to an acceptable performance and preserves its basic identity. Re-use involves using a product more than once without reprocessing; it helps save time and resources while still making quality products available to those with limited means.

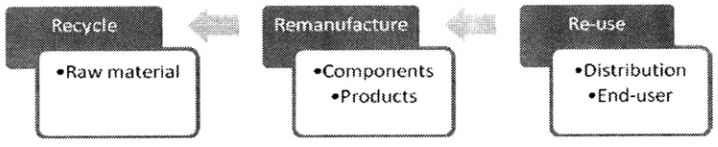

Figure 3.4: Reverse logistics flow [35]

The use of cleaner alternative means with an objective of pollution prevention has not been as widespread. 3M [35], one of the few companies who has taken such an approach had reported that it has saved them $800 million since 1975. Such an approach also placed fewer constraints on every stage of the supply chain as it required the joint efforts beyond a particular manufacturing or distribution facility instead it included a broader set of suppliers and customers (Figure 3.5).

Figure 3.5: Supply chain & Environmental orientation strategies [35]

Recently, building a picture of the carbon footprint of a product by measuring emissions across the supply chain is a growing trend (Figure 3.6). The carbon footprint of a product is the carbon dioxide emitted across the supply chain for a single unit of that product. It can help supply chain managers identify the largest emission sources across the supply chain and prioritize the emissions reduction opportunities.

[53] Primary reasons for this growing interest in sustainability and energy efficiency in supply chains are as follows:

- cap and trade regulation by which governments could pressure companies to limit the amount of carbon they release
- customers who favor companies that show reduction of carbon emissions

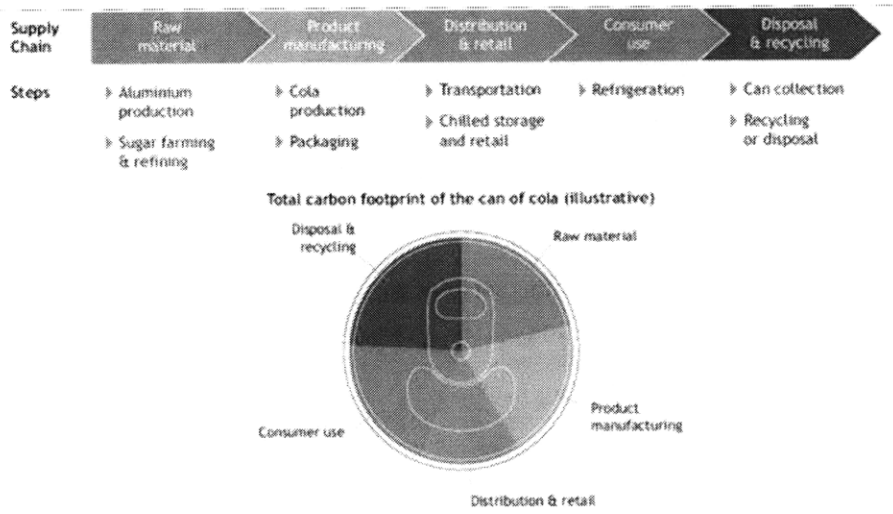

Figure 3.6: Illustrative supply chain of a can of cola and its carbon footprint [11]

[53] By understanding the carbon footprint, managers are now able to recognize the extent to which the carbon emissions are related to their specific needs, versus those inherent in the supply chain. Such a differentiation allows them to make more informed choices in material, equipment or supplier selection (Figure 3.7); or offsetting the unavoidable emissions through credit trading or other means. [11] Carbon saving opportunities can therefore be categorized as follows:

- correction of a market failure wherein incentives create extra emissions
- product mix or configuration change to reduce total emissions across the supply chain
- supply chain re-configuration wherein changes to specific flows and processes could reduce emissions

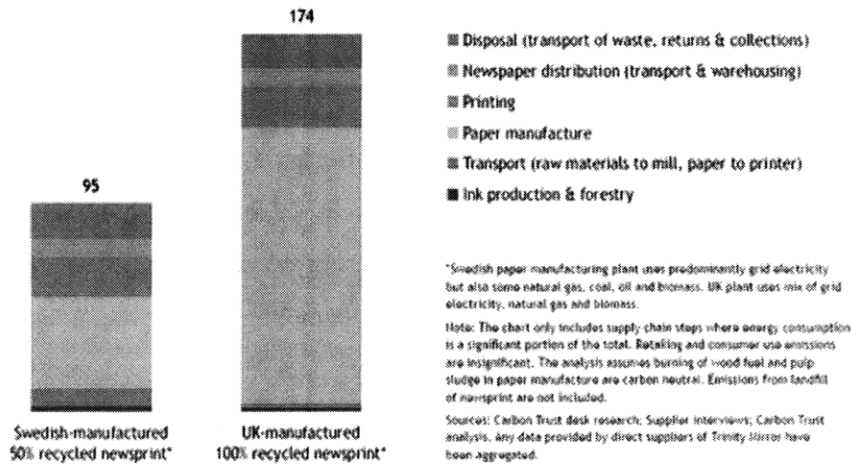

Figure 3.7: Comparison of carbon footprint for different newspaper suppliers (g CO2 per final newspaper sold) [11]

3.5 Product Innovation

Supply chain strategy assessment [47] maybe required if the distribution cost is a major component of the total product cost or if a product innovation changes to the current distribution method. In some cases the distribution efficiency could be a key success factor in product launch, for example damage free delivery or when the logistics capabilities are the basis for competition. [64] Leading companies invest twice as much on introducing supply chain innovations for customer satisfaction and cost control than followers. In this regard, industry-wise, computer and peripherals sector have the highest maturity where as region-wise, northern Europe has the greatest supply chain maturity, namely UK, North Ireland, Scandinavia.

[19] Supply chain development can be divided into the supply chain architecture decision, and the logistics/coordination decision. Supply chain architecture decision includes make or buy, and choosing which companies to include in the supply chain and how to contract with them. Logistics and coordination decision includes inventory, delivery, and information systems to support ongoing operation of the supply chain.

Aligning the product architecture with the supply chain architecture is essential for both radical and incremental innovations. [7] Cost and time are perhaps the two most important factors essential to optimizing the return on investment for new product development. Strategies for cost reduction such as increasing the level of commonality of components and increasing the reuse of platforms can also help revenue growth, by improving time-to-market. To be effective, such strategies rely on supply chain's ability to efficiently manage product transitions and new, derivative product launches, with upstream and downstream partners. While a new logistics infrastructure maybe needed for the latter, lowering costs without affecting service levels could be crucial for the former [47].

For instance, [61] in the telecom industry, Nokia is constantly reducing its number of suppliers to ease device complexity. For instance its preference for vertically integrated suppliers, a departure from allowing integration of a large number of components sourced from third party suppliers. Such changes have been viewed as essential to support Nokia's time to market and product performance for a rapidly changing product mix. These changes have required suppliers to invest in bringing the related competencies in-house. Nokia's resulting pare down to 3 low cost manufacturing locations in China, India and Mexico could be attributed to both emerging markets as well as to the fact that suppliers in Europe were slow to align their operations with such industry trends.

3.6 Integration

In a study of integration at European companies [3] over 75 percent of the participants confirmed that their companies have installed some modules of ERP systems. While involvement of key suppliers was high in R&D, procurement and distribution, it was surprisingly low in inventory management, manufacturing, supply chain design, and implementation of supply chain software. Companies that have high level of upstream and downstream integration have seen significant improvements in their logistical performance. On the contrary, integration with customers that is not supported by upstream integration is generally viewed as reducing margins [4]. Though integration

provides the foundation upon which a well running Sales and Operations Planning (S&OP) can be implemented. Yet [62] it was found that only 17% of managers say that their S&OP effectiveness is good; while another 17% say that they do not have a formal S&OP process; with the remaining either calling it ineffective or reasonably effective, impeded by low levels of electronic collaboration, data quality and business case and leadership. This could be a major obstacle in being responsive to customer demand in light of increased off-shoring. [7] The increasing complexity of products and markets has caused companies to implement advanced planning systems on top of their integrated systems, in an effort to increase their capability to detect market changes and respond quickly through better collaboration with partners. Integration when viewed from an end-to-end supply chain perspective improves visibility of key supply chain processes and supports optimizing supply chain performance. Supply chain integration broadly includes the following:

- shared information about plans and execution to support collaborative and quick decisions
- real time access to transactions for timely troubleshooting of issues
- event alerts for early warning of an emerging trend
- shared and aligned metrics to assess routine performance
- scorecards for trends and recurring concerns

Supply chain integration is also essential to improve collaboration and coordination with upstream and downstream partners. Coordination mechanisms require that supply chain managers be careful in timing transactions; clarify issue handling; and increase cross-functional involvement.

Coordination mechanisms can be categorized as follows [23]:

- price coordination: quantity discounts, two-part tariffs or buy-back/returns policy
- non-price coordination: quantity flexibility, allocation rules, promotional allowance/co-operative advertising, exclusive dealings or territories
- flow coordination: VMI, QR, CPFR, ECR, postponement [Sahin and Robinson 2002]

Supply chain collaboration can also be categorized as follows [83]:

- supply chain process automation which is focused on incrementally improving performance through benchmarking; increasing process efficiency for established processes; and using return on investment to justify investments
- supply chain process innovation which is focused on gaining and maintaining competitive advantage through process changes; evolution from push-based to a pull-based or hybrid model; and revolutionary approaches such as tailored supply chains

It is also believed that European companies must look at RFID integration for improved supply chain visibility in response to increased offshoring; improvement in operations; track and trace; and returnable asset management [54]. Nevertheless, RFID activity at end-user level is still low in Europe, with 15-20% planning a RFID pilot in Europe relative to 50% in US. Some of the obstacles that have been listed are lack of congruence of standards; power output restrictions; read rate; building structure implications; ambiguous records and distance; and data collection and security at enterprise level Another notable difference is that suppliers would be required to bear most of the cost in US.

Chapter 4: Empirical Study

Please also refer to Appendix A3 (page 84) for additional details regarding the survey.

4.1 Pilot Study

Ten supply chain managers representing companies in consumer electronics, automation systems, diversified manufacturing of industrial and consumer goods, retail and logistics services, consistently chose the following focus areas from the literature review, for further investigation:

- profitable demand fulfillment in emerging markets
- outsourcing and assembly in developing countries
- sustainability and regulatory compliance
- product innovation
- multi-modal transportation
- supplier and customer integration in planning and execution cycles.

4.2 Survey Development

While this study includes a review of past literature and a pilot study for expert opinion, an empirical study of this nature cannot capture every aspect of the supply chain. Its scope is limited to the focus areas identified during the above pilot study. The survey developed for this study is aimed at building a holistic comparison between European and US supply chains. Past studies that compare European and US supply chains have focused on a specific supply chain process, such as third party logistics services; supplier selection; or integration, not undertaking a more holistic comparison between the European and US supply chains. The survey developed for this study is divided into seven areas namely,

- supply chain characteristics
- supply chain objectives and metrics

- supply chain configuration- markets and distribution, procurement and manufacturing, and transportation
- sustainability
- product innovation
- integration and
- risk.

Within each of these seven areas, managers were asked questions based on a five point Likert-type scale. Some of the questions are open ended with the intent that the responses received would be categorized prior to analysis. Furthermore, due to the project sponsor's strong European connection, the sample had more European companies than US companies. The breadth of topics covered by the survey could also cause managers to not respond, either because they do not have visibility to the information being asked or because they choose not to divulge it for competitive reasons. To address these limitations, more than 400 companies were enlisted for response. Follow-up emails and telephone calls were planned every two weeks over a period of eight weeks. The survey was pre-tested by two selected supply chain managers and refined to reflect their feedback.

4.3 Survey Administration

The survey was administered electronically via surveymethods.com. This eliminated mailing delays, kept costs low and supported efficient data analysis. 431 supply chain managers across Europe and US were invited to respond to the survey. An estimated 390 supply chain managers received this invitation via the surveymethods.com web link. This estimate does not include the invitations that were returned as undeliverable or out-of-office, however it does include those who fully or partially completed the survey, formally opted out, informally declined or did not respond. The survey responses from Europe and US were stored in separate data tables. The survey was closed in the eight week after launch.

4.4 Survey Response Data

Upon closure of the survey, the survey response data was processed as follows:

1. Re-coding of the answers submitted by 110 supply chain managers was completed to make the data suitable for statistical analyses in STATA. Responses to open ended questions were translated into categorical values per the system outlined in Table 4.1.

From	To
Detailed Supply Chain Description	Categories such as Chemical supply chain, Beverage supply chain, Agricultural supply chain..
Detailed Supply Chain Characteristics	Simplified Notation for Industry, Geography and Supply Chain Type
Top Supply Chain Objectives	Categories such as ServLvl, CostOper, NewProd...
Top Supply Chain Metrics	Categories such as FillRate, InvLvl, CostUnit
Top Emerging Markets	Categories such as Eastern Europe, China, India, Russia.
Top Supply Chain Changes	Categories such as NetworkRedesgn, Multimodal Transport…
Top Supply Chain Risk Measures	Categories such as Flexibility, Redundancy, CommdPrce …
Metric values	Categories such as Revenue up to 50MM, up to 500MM, more than 500MM…

Table 4.1: Recoding scheme for open ended responses

Responses to all Likert-type scale questions were translated into variable name and values per the system outlined in Table 4.2.

From	To
130 Descriptive Questions	130 variable names with prefixes to denote the relevant SC topic namely, SC Objectives, Product Innovation, Risk, Sustainability…
Responses such as- 1 Strongly Disagree, 2 Disagree, 3 Neutral, 4 Agree, 5 Strongly Agree	Agree- if response is 4 or 5 Disagree- if response is 1 or 2

Table 4.2: Recoding scheme for Likert-type scale questions and responses

2. Univariate analysis was performed on each of the above variables, to discover the distribution of responses across different industries, current geographies of operations, objectives, emerging markets, risk measures, metrics, and major areas of agreement and disagreement in the areas of supply chain configuration; risk; sustainability, product innovation; and integration. Percentage bar graphs were used to present the results of this univariate analyses.

3. Bivariate analysis was performed on a number of key variables that were identified as major areas of agreement. The objective was to discover variables with high correlation. For example: a supply chain that has maximizing profit as a supply chain objective is also most likely to have fill rate segmentation or order allocation as a supply chain objective. Each of the major areas of agreement was compared with every supply chain configuration variable to uncover the drivers, challenges, experience to-date, and future opportunities in this area.

4. Results of the above analyses for European and US supply chains were placed side by side for comparison purposes.

4.5 Survey Participants

Broadly, the sectors represented by the managers who participated in this study are- consumer, retail, industrial, high-technology and transportation (Figure 4.1). Notably, in the technology sector, nearly three times as many companies were from the US versus Europe. On the other hand, in the consumer products sector, nearly twice as many companies were from Europe versus the US. The product focus of the participants' supply chains were electronics; personal care; confectionary; automotive; fashion and sporting goods; beverages; tires; aerospace; safety products; spare parts; construction; energy; metals; chemicals; agricultural and forest products; semiconductor; and network components (Table 4.3). The geographic locations of participants' operations are shown in Figure 4.2.

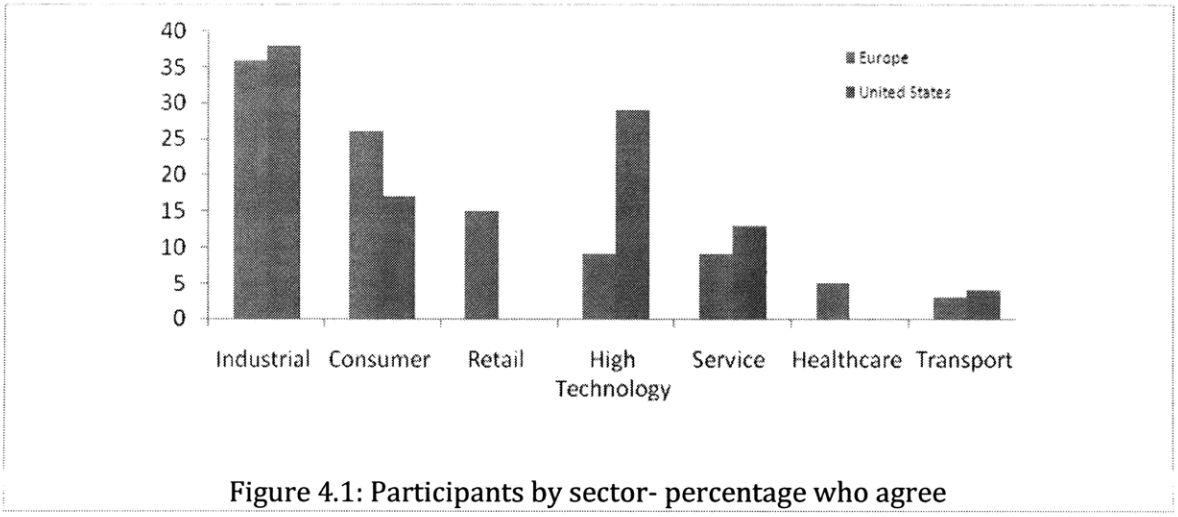

Figure 4.1: Participants by sector- percentage who agree

Sector	Product focus of participating supply chains
Industrial	Electrical, Pesticides, Fluid Valves, Safety, Spares, OG, Construction, Energy, Cement, Plastics, Metals, Chemicals, Agriculture
Consumer	Electronics, Apparel, Beverage, Lighting, Tobacco, Personal Care
Retail	Confectionary, Automotive, Fashion, Apparel, Sporting, Tyre
High Tech	Semiconductor, Aerospace, Network Components, IT Wholesale
Service	Logistics Services, Supply Chain Finance
Healthcare	Medical Device, Pharmaceuticals
Transport	Chemicals, Forest

Table 4.3: Product focus of participating supply chains by sector

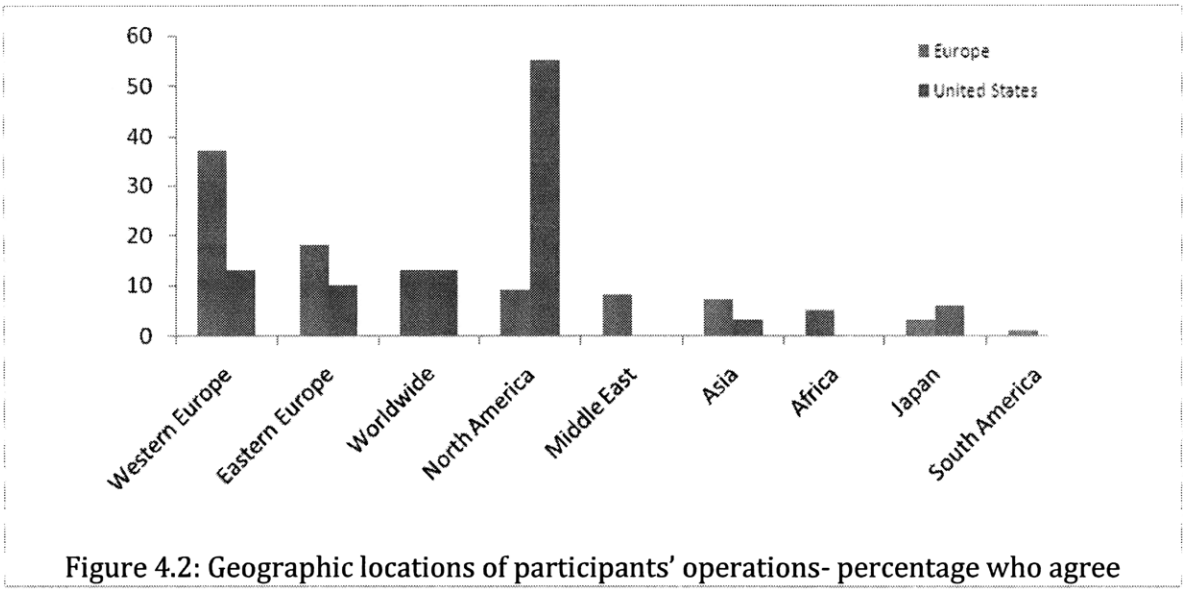

Figure 4.2: Geographic locations of participants' operations- percentage who agree

Chapter 5: Analysis of Survey Response Data

Please also refer to Appendix A4 (page 93) for additional details regarding the bivariate analysis.

5.1 Characteristics

More companies in Europe identified their supply chain type as make-to-stock (Figure 5.1), whereas make-to-stock, make-to-order and service were the commonly noted supply chain types among the US respondents. Nearly an equal number identified their supply chain as cost efficient or flexible response (Figure 5.2).

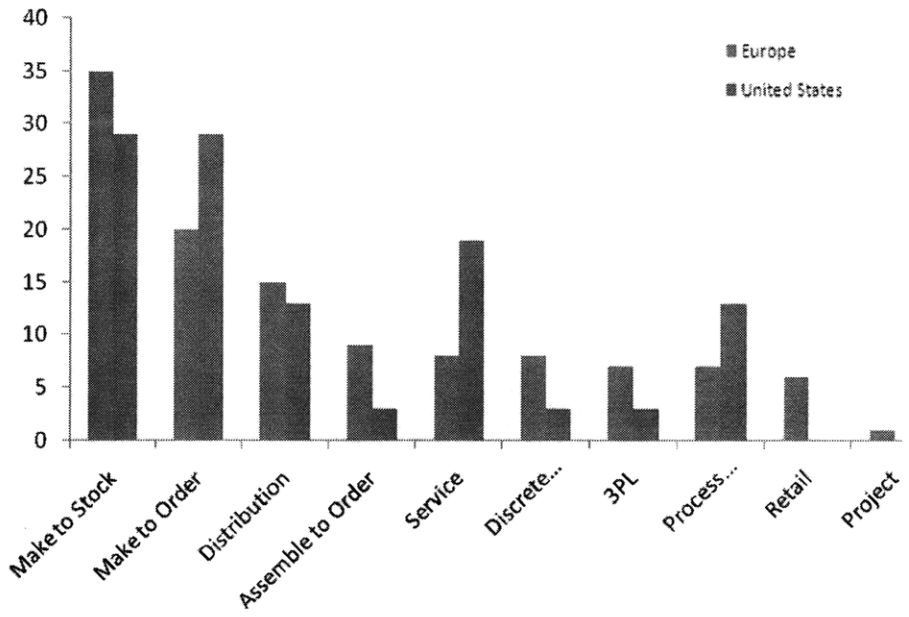

Figure 5.1: Supply chain types- percentage who agree

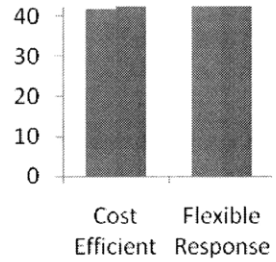

Figure 5.2: Supply chain strategies- percentage who agree

5.2 Objectives and Metrics

When asked about their supply chain objectives, European and US supply chain managers listed cost, response time, customer and inventory as the key focus areas (Figure 5.3). Interestingly, nearly a third of the objectives listed by European managers had a cost focus, and roughly one out of every four had a customer focus. This trend was reversed among the US managers, where nearly a third of the objectives listed had a customer focus and roughly one out of every four had a cost focus. This inclination was also supported by the key supply chain metrics listed by managers, where cost metrics were more common among the European companies and customer metrics were more common among the US companies (Figure 5.4). Currently, nearly ninety percent of supply chain metrics at European and US companies are made up of cost, customer, inventory and time. There is therefore some misalignment between the stated supply chain objectives and metrics. For example, there are not many metrics supporting the stated supply chain objectives of risk mitigation, optimization and integration. In the future, for European supply chains, we could expect to see more objectives with a customer focus and introduction of more metrics for supply chain risk, optimization and integration.

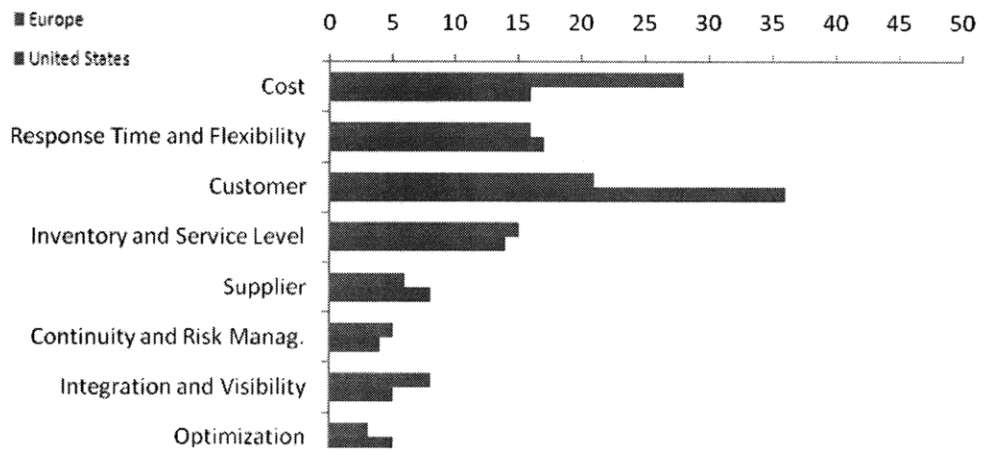

Figure 5.3: Supply chain objectives- percentage who agree

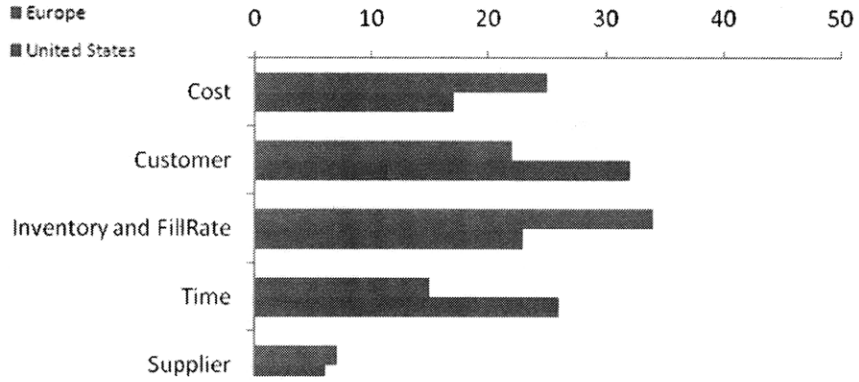

Figure 5.4: Supply chain metrics- percentage who agree

Next, I discuss the specific findings and insights in each of the five areas of supply chain configuration: risk, sustainability, product innovation and transition and integration. This discussion is just one of the many conversations that could occur over the next few years, as companies begin to apply the insights from this study to their businesses.

5.3 Supply Chain Configuration

Demand from emerging markets and procurement from suppliers in these markets could be the primary engines that drive new supply chain configurations (Figure 5.5). The commonly identified emerging markets were Eastern Europe, Russia, India and China. However, due to the recent volatility in energy costs and the broad unavailability of a comparably developed infrastructure in emerging markets, many managers agreed that a multi-tiered distribution structure, supported by multi-modal transportation, will be needed to increase responsiveness and improve cost efficiencies in these markets. In transportation, more than 70% of managers agree on including full life cycle energy and carbon footprint measures in their supplier selection criteria, and on increasing the use of multimodal transportation. This area offers promising opportunities for transportation carriers. For example, carriers could now construct multiple origin-destination (O-D) itineraries for their shippers as a function of parameters such as carbon footprint, cost and time. These itineraries could be priced by taking into account the value they provide to the shipper; and the sensitivity of regulators and consumers to this value, thus shaping the shipper's carrier selection.

Of the European managers, 70% expect an increase in emerging market supply. Therefore, on both the demand and supply side, supply chain managers will be paying more attention to preparing their companies for a successful implementation of supply chain policies that match the new configuration.

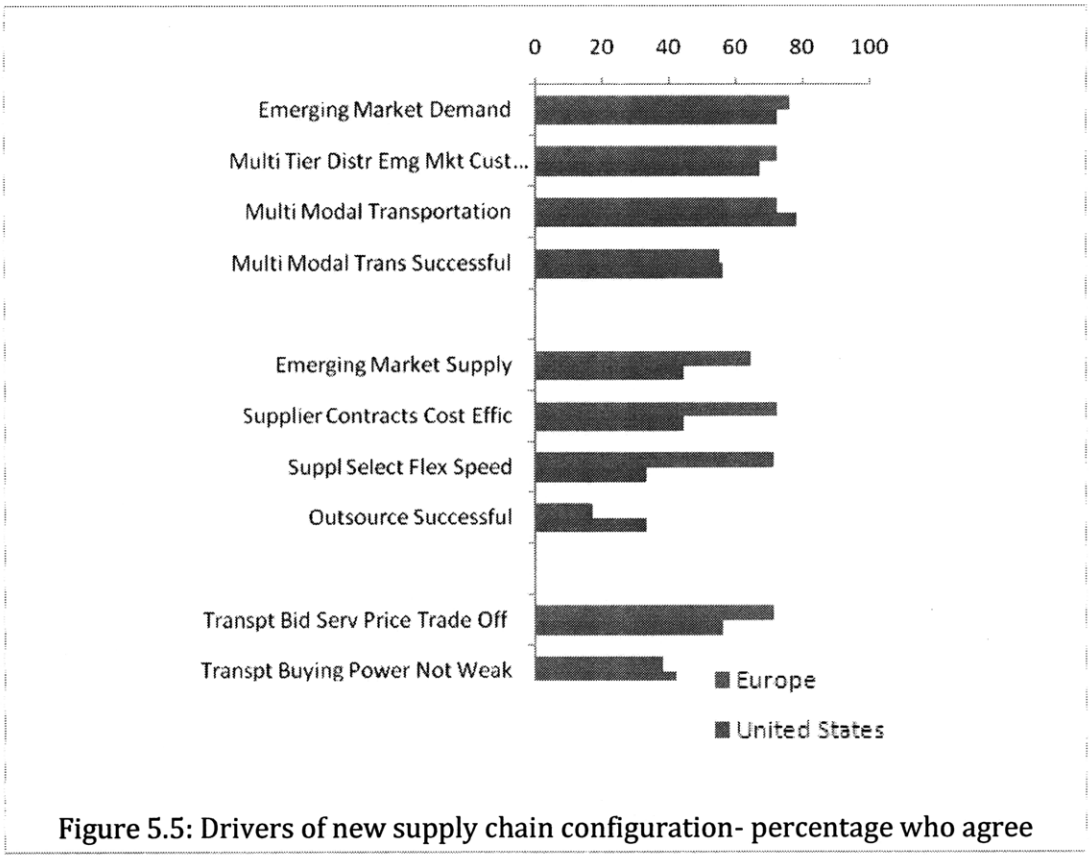

Figure 5.5: Drivers of new supply chain configuration- percentage who agree

This could include a re-optimization of the overall inventory level with more stocking locations, along with an increase in the use of flexibility in the procurement and manufacturing strategies to balance inventory costs with transportation costs. In addition, although 75% of European managers have said that they depend on contracts for a cost-efficient and effective supply, they seem to have achieved limited success with their overall implementation. For example, only one out of five has reported that the outsourcing of manufacturing operations has been successful. The supply chain function that connects to and manages external competencies for a company will therefore now be required to take a leading role in addressing this unpromising viewpoint on outsourcing. The successful contracting and coordination capability of a company's supply chain function will be increasingly seen to be as important as other company-specific capabilities or advantages in product development, marketing or sales.

It is known that adapting to changes in markets is essential for global supply chains to remain efficient and competitive. Recently, there have been significant changes in labor costs, the price of oil, and uncertainty in long lead times. [74] Specifically with regards to labor cost, the average annual wage increase (2003-2008) is estimated at around 21% at Brazil, 19% at China, 8% at Malaysia, 5% at Mexico and 3% at US. During the same period, the increase in US domestic transportation costs corresponding to an increase in crude oil price from $30 to $75-$125 is estimated to be between12%-26% ($/mile for Truck Load). [1] Similarly, the 19th Annual State of Logistics Report noted a 52% increase in total annual logistics cost in the US from 2002 to 2007, mainly due to a 47% increase in transportation costs and a 62% increase in inventory costs. These changes may require supply chain managers to think about moving production from offshore to near shore or inshore. For example: offshore production to the Far East when transportation cost per unit (weight, volume etc.) is low and the US production cost per unit is high; inshore production at US when the transportation cost per unit is high and the US production cost per unit is low and; near shore production at Latin America when both the unit transportation cost and unit production are in between.

[91] Consider the case of Sharp, a leading global manufacturer of consumer electronics that recently moved its TV production facilities from Asia to Mexico in order to serve customers in North and South America. This move was driven by the need to keep shipping costs low and the lead time to market short. Reducing the shipping time to market from about 40 days when production was in Asia, to 7 days when production was moved to Mexico, has had a huge impact on the company's bottom line, especially because the retail price of a flat screen TV falls rapidly. [87] In another instance, Steiff, a privately-owned German toy manufacturer that had moved around 20% of its production to low cost countries with the objective of cutting cost and competing on price, has recently started moving production back to Germany, Portugal and Tunisia. The reasons cited were quality problems and high transportation costs. An analysis [71] of the supply chain configuration for a consumer products company showed that for the first few $25 increments in rising crude oil prices, transportation costs would impact profitability but not the configuration.

However, at $150- a- barrel crude oil, the rise in transportation costs starts to impact the trade-offs between manufacturing costs and inventory costs. Adding more distribution centers into the configuration so that the company is closer to its customers reduced the outbound shipping costs more than the corresponding increase in inventory costs. More specifically, with crude oil at $75 a barrel, the optimal manufacturing mix for this company was to produce 22% volume near Philadelphia and 78% near Juarez. At $200 crude oil, the production volume near Philadelphia increases by just 1% to 23%, however the Juarez production volume drops to 54% and Omaha enters the configuration with 23% production volume -- i.e. the higher manufacturing costs in Omaha are being offset by lower transportation costs versus Juarez. Similarly, on the DC network side, up to $125 oil, the optimal supply chain configuration remains the same -- Atlanta, Chicago, Dallas, New York and Las Vegas. But at $150-a-barrel crude oil, Las Vegas DC is replaced with Albuquerque, Los Angeles and Portland.

In summary, changes in the supply chain configuration of companies could come more quickly in some industries than others. The pace could be determined by the basis for competition between players within the industry which might be: increased emphasis on better service; reducing expediting costs; less offshore production to reduce total landed costs; improving quality and compliance with security requirements (such as those being developed by the European Organization for Security), or a combination of these factors. [71] For products such as toys and footwear, where the impact of transportation costs is high and the cost of moving infrastructure is low, near shore procurement may be seen as viable. For products such as mobile phones and PCs, where the cost of moving infrastructure is high and the impact of transportation cost is low, offshore procurement may continue to be viable. For products such as TVs, refrigerators, appliances, car parts and furniture, where the impact of transportation is high, depending upon the cost of moving infrastructure, near shore assembly may be seen as viable.

5.4 Risk

Foremost on the minds of supply chain managers is the growing importance of their company's ability to understand and address potential disruptions throughout the supply chain. Nearly 70% of supply chain managers agree that the use of standard practices across business units for a central view of the impact of a supply chain risk on the business is generally absent. Beyond entering into performance contracts with suppliers at the business unit level or passing on cost increases to the customers, few reported use of inventory, redundancy or transportation-related risk measures (Figure 5.6). In the future, a quantitative assessment of the impact of different risk levels on cash flows and the use of options contracts to minimize exposure to risk will be seen as standard risk mitigation practices for businesses. Such an approach can also create a solid foundation for the equitable sharing of risks, costs and gains from risk-mitigation initiatives.

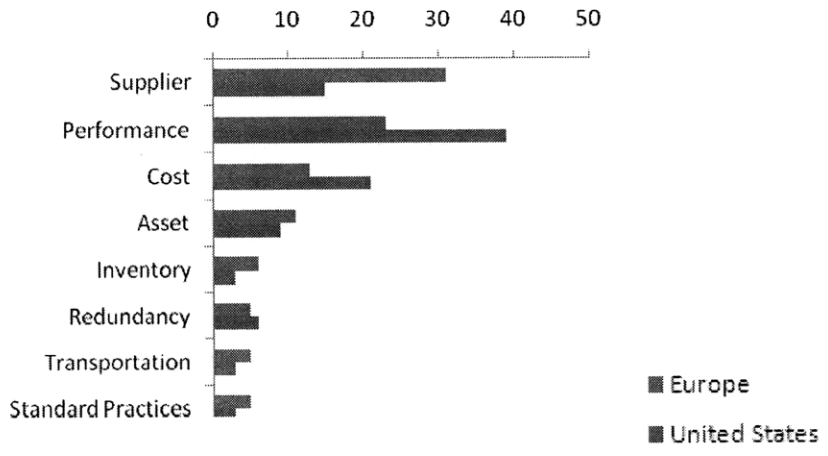

Figure 5.6: Risk measures- percentage who agree

The broad acknowledgement of risk (Figure 5.7) in internal operations, both on the supplier side and on the customer side, points toward the gradual introduction of a measured level of redundancy in future inventory policy. Combining an increase in safety

stocks with an increase in manufacturing flexibility through postponement strategies may be progressively seen as an acceptable and viable risk mitigation approach. This will be particularly true as the low finished and work-in-process inventories inherent in lean inventory policies increase the chance of stock outs in different stages in the supply chain, further amplifying demand variability and leading to more severe stock outs that can eventually cause an increase in the risk of customer order cancellations.

Overall, the risk concerns expressed by supply chain managers in the US were higher. This could be due to more experience responding to high impact events such as hurricane Katrina, safety-related product recalls and the West Coast port strike. Objectives such as using available technologies such as RFID and high speed data analysis for ensuring shipment integrity and monitoring are also seen as important from a customs view point for border and supply chain security. We may therefore see an adoption of a comprehensive risk management framework that includes as inputs, information from key stages in the supply chain (procurement, manufacturing, field sales and service locations). Additionally, in the future, supply chain managers could also be expected to partner with finance managers to prioritize and present key risk measures alongside performance measures.

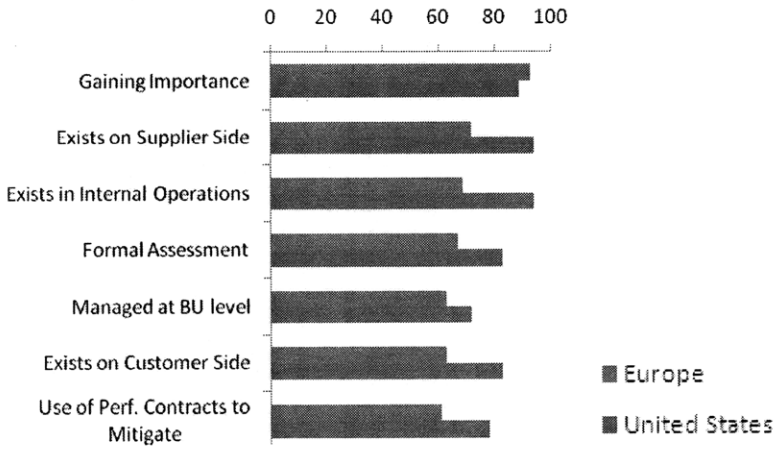

Figure 5.7: Risk assessment- percentage who agree

Companies more often than not, experience supply chain risk from factors such as demand uncertainty, quality issues, customer expectations, global competition and long interdependent supply chains supporting shortening product life cycles. Recently, natural disasters and geo political tensions and insurgency have been included in this list [68.316]. In competitive markets, companies that respond to a supply chain disruption quickly can maintain or improve their market leadership. Consider the case of a US-based consumer packaged goods (CPG) manufacturer, with a global network of 40 manufacturing facilities and many distribution centers [68.318]. When analyzing its network for plant rationalization, the company found that it could save $40 million annually by closing down 17 of the existing facilities. However, there was concern that this optimized plant rationalization suggested shutting down all plants in North America and Europe while it maximized the utilization of manufacturing facilities in Asia and Latin America. Any disruption of supply from Asia and Latin America would make it difficult to meet the demand in these market areas. Through a cost trade-off analysis (Figure 5.8), the company found that having 7 more plants near the optimal configuration solution resulted in a configuration with a slight increase in total cost of about $2.5M but substantial reduction in risk. This is an instance where although the supply disruption risk could not be reliably measured, the company reduced the associated risk by adding some redundancy into the supply chain.

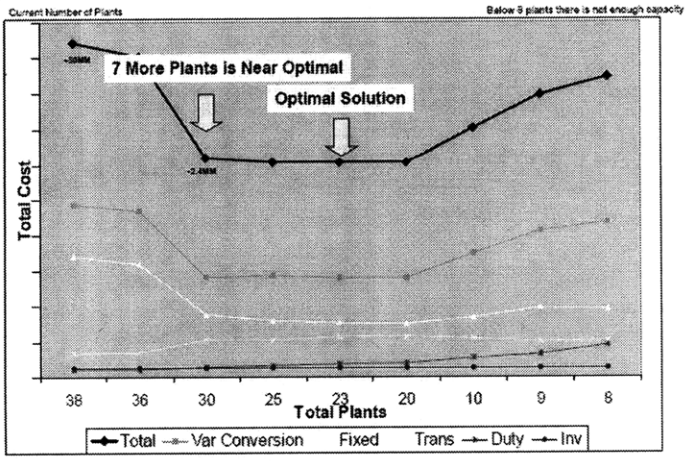

Figure 5.8: Cost trade-offs in supply chain [68.318]

In summary, supply chain managers can provide real value in addressing the significant increase in the level of supply chain risk over the past few years. While inventory held at different points in the supply chain for risk pooling also makes the overall supply chain more efficient, putting together either a forecast that factors in the risk of supply disruption or predicts every possible scenario to determine the best fit, is a daunting task. Therefore, an alternative approach could be to work out the lowest cost portfolio and add in some redundancy to cover risk [70].

5.5 Sustainability

Many expect sustainability-related supply chain changes as a response to government regulations and are concerned about the impact of a cost increase due to the lack of common criteria across the supply chain. An assessment of sustainability initiatives and concerns in the supply chain (Figure 5.9) shows that growing concerns about greenhouse emissions resonate among both European and US supply chain managers. Overall, the concerns expressed by supply chain managers in the US were higher. This could be due to greater experience with sustainability initiatives on the European side, in response to prevailing EU regulations in this area.

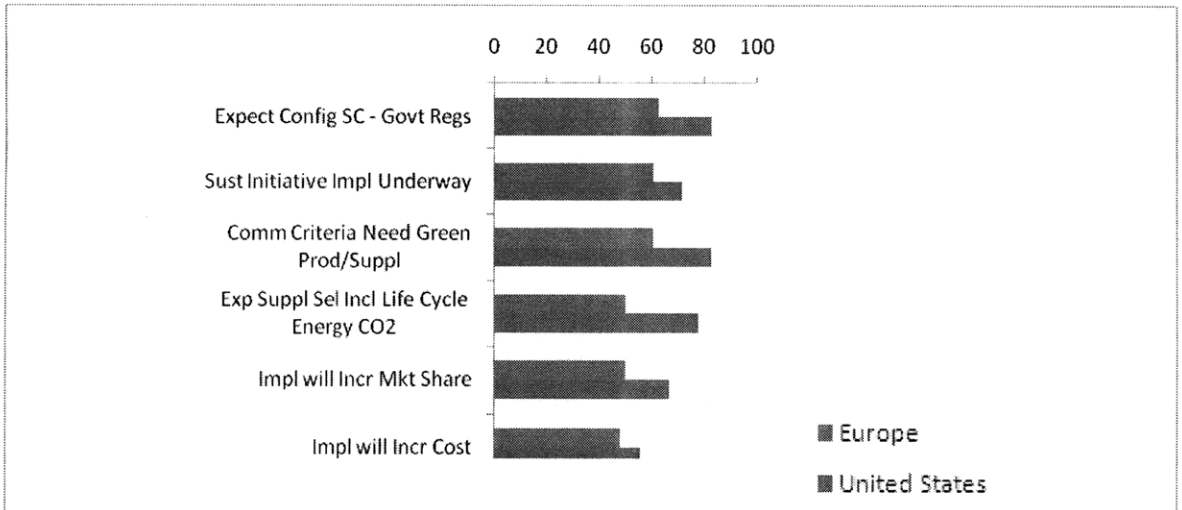

Figure 5.9: Sustainability assessment and concerns- percentage who agree

Many managers have said that in the future, measures for full life cycle energy and carbon footprint will be included in their supplier selection criteria. However, they are doubtful about the implementation of practices that capitalize on potential business opportunities beyond compliance with government regulation. The systemic nature of the sustainability challenge will cause companies to increasingly rely on supply chain managers to expand the attention to energy use and pollution control beyond internal operations. An increase in the use of voluntary standards, as opposed to regulations, can result in the creation of common criteria that the same number of managers said is needed to determine how 'green' a product or supplier is.

Interestingly, 50% of managers have also said that implementation of sustainability or green supply chain initiatives will increase both supply chain costs and market share. This can be an opportunity for the supply chain function to be a key partner of the internal product innovation team, in an effort to design and incorporate improved environmental performance into the products. The benefits from alignment, and the costs of misalignment of sustainability initiatives, are unbalanced across the supply chain; still supply chain managers will continue to face the growing need for identifying, selecting and implementing green supply chain practices. With financial incentives in Europe to cut carbon emissions; the expectation that high carbon emissions mean low SC efficiency; possible future US legislation that is more in line with regulations in Europe and the demands of consumers, companies will explore a supply chain configuration that satisfies customer demand yet minimizes carbon emissions. The key is to find the right trade-off between cost, service and carbon emissions.

Additionally, it should be noted that the reduction in energy use also reduces the uncertainty surrounding supply chain costs from volatile crude oil prices [71]. An immediate next step could therefore be to understand the company's carbon footprint as it relates to transportation (emissions per ton-mile), warehouses (emissions per kWh and energy use kWh per sq.ft. or inventory volume), plants (emissions per kWh and energy use kWh per sq.ft. or production hour) and production (kWh per unit). To aid managers in conducting such analyses of their own supply chains, data sources available from the US

government and the World Resources Institute include [85] a) carbon emissions by fuel type; b) average fuel efficiency values; c) carbon-freight factors for waterborne and rail d) electricity emissions factors by US State and country; and e) electricity consumption by building characteristics – building size, geographic region, number of workers, principal activity and year constructed.

Consider the case of Wal-Mart [89]. Around October 2005, CEO Lee Scott presented an environmental plan to reduce energy use and greenhouse gas emissions not only on the company's own operations but in its suppliers' operations as well. The target was to cut greenhouse gas emissions by 20 percent by 2012. In 2008, the retail giant started rating its providers' performance on an environmental score card that included greenhouse gas emissions, cube utilization, recycled content and renewable energy. As a result, its 3PL provider in Canada changed the shipment of products to 10 stores in Nova Scotia and Prince Edward Island from road to rail, resulting in a reduction of 2,600 tons in GH emissions. In addition, the 3PL provider converted 20 truck generators to electric power, saving about 10,000 gallons of fuel. These two measures combined are expected to yield more than $2 million in annual cost savings. In another instance, Dell's sustainable supply chain initiatives included [84]

- a change in transportation mode from air to ground, which generates a seventh fraction of the carbon emission from air transport
- an increase in the success of first time delivery to reduce transportation cost and carbon emissions, by eliminating the need for a re-visit and
- use of modern packaging technology that reduced damaged shipments -- and therefore returns -- while maximizing space utilization in every shipment.

A sample strategic trade-off analysis (Figure 5.10) shows the impact on a company's carbon footprint, production, shipping and warehouse costs as a function of the number of its distribution centers (DCs) [88]. In the cost minimization scenario with four DCs, the warehouse fixed costs increase, the cost of inbound shipments to the DC decreases, and the cost of outbound shipments to customers also decreases, resulting in a total cost reduction with a corresponding carbon footprint reduction. However, it can be

seen that a distribution strategy that includes six DCs is also an attractive alternative if the 1.6% cost increase is acceptable for gaining an 11% reduction in carbon footprint. It could be argued that in such cases, a relatively small carbon credit would make the additional 11% carbon footprint reduction economically sound.

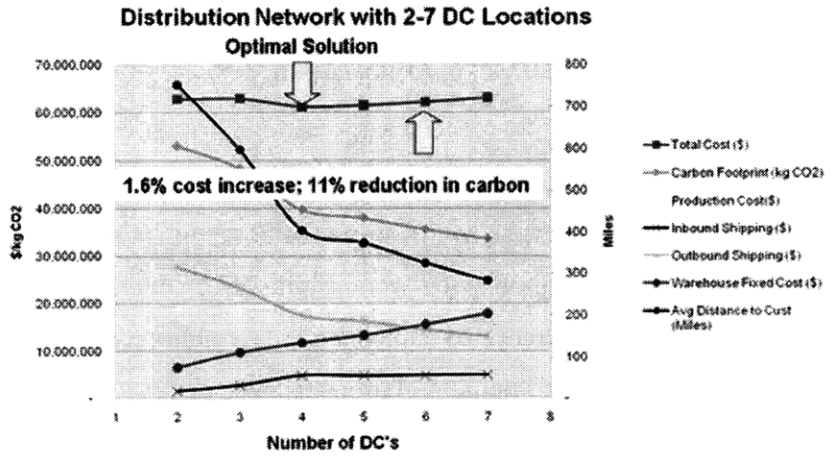

Figure 5.10: Trade-off curve between number of DC's, cost and carbon footprint [88]

In summary, to build a company's value-enhancing capabilities, supply chain managers will be increasingly required to undertake sustainability initiatives. Such initiatives could go beyond regulatory compliance to meeting customer and corporate environmental goals. Sustainability in supply chains has the potential to become a true competitive differentiator that proves the supply chain manager's belief that such initiatives will increase market share. The absence of such an approach will drive companies to internalize environmental costs from manufacturing, use and post- consumption, creating a possible competitive disadvantage.

5.6 Product Innovation

Nearly an equal number of supply chain managers in Europe and the US have said that synchronizing product innovation across the supply chain will grow in importance, and that it is a determinant of a company's leadership status in the supply

chain (Figure 5.11). A significantly larger number of European supply chain managers indicate that existing product transition teams do not include customers. Also, a greater number of supply chain managers in Europe disagree that the internal supply chain function or suppliers are proactively involved in an effort to better synchronize production innovation decisions. This is perhaps due to the structural and cultural differences between European and US companies. US companies are decentralized to a lesser degree and have more experience base with faster clockspeed industries, two factors that affect the level of internal and external cross-functional participation that is considered necessary for managing product transitions. While the extent of supply chain involvement is known to be a positive influence on new product success, it still is an area of more opportunity in Europe. Beyond the infrequency of radically new products wherein the priority of a supply chain manager is to get the product launched, increasing supply chain cost efficiencies for incremental innovations is also equally important.

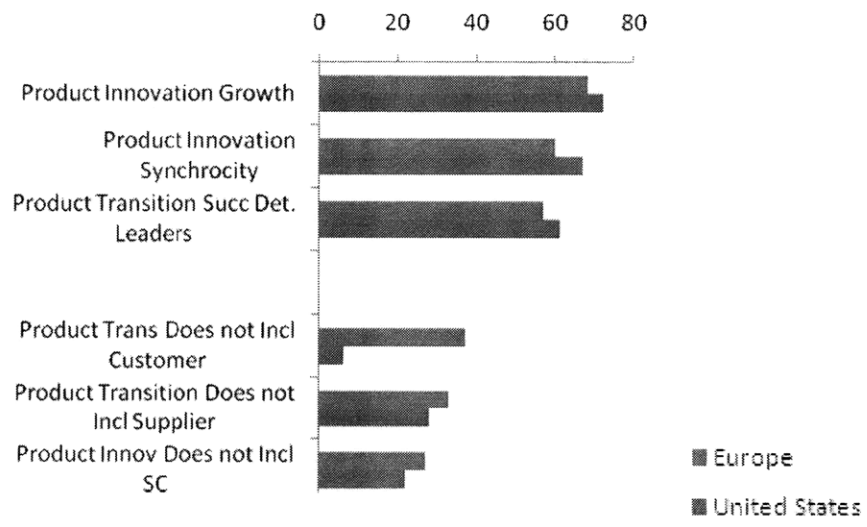

Figure 5.11: Product innovation assessment- percentage who agree

In this regard, it could be noted that in order to create the right supply chain strategy for product innovation, supply chain development decisions must be made concurrently with product and process development [19]. As noted by Professor Fine,

supply chain development includes supply chain architecture decisions (make/buy, partner selection, contracting, etc.) and the logistics coordination decisions (inventory, delivery, information sharing, etc.). Concurrency of these decisions with product and process development is critical when the competitive impact of the supply chain decision can extend over several generations of the product.

Product and supply chain architectures are typically aligned and mutually reinforcing. For instance, integral products are developed and built by integral supply chains, whereas modular products are developed and built by modular supply chains. Modular product architectures allow the supply chain to operate in pull-mode [68.340] and be more responsive when both product innovation frequency and demand uncertainty is high, as in the case of cell phones and PCs (Figure 5.12).

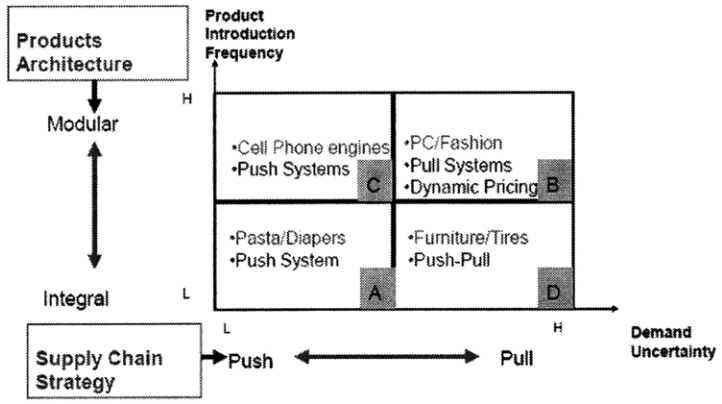

Figure 5.12: Product architecture and supply chain strategy [68.340]

On the other hand, an integral architecture may be more appropriate when product innovation frequency and demand uncertainty is low, as in the case of pasta and diapers, because it allows the supply chain to operate in push mode. Similarly, for high demand uncertainty with low frequency product innovations and an integral architecture, a push-pull supply chain could be effective, as in the case of furniture and tires.

Consider the lean production system that was developed within the highly integral Nagoya/Toyota city supply chain. Toyota and its principal suppliers concentrated in a geographic region and shared a common business and social culture. However, when Toyota began off shoring production to California and Kentucky, globalizing the entire Toyota system of concurrent product, process and supply chain development was not problem-free [19]. The launch of Toyota's US Camry and Avalon vehicles was delayed by 10 months with an increase of nearly 40% in development costs. Toyota's costs were nearly $1 million per month just for expediting shipments of critical parts from backup suppliers in Japan. In this instance, the supply chain development had architecture problems -- partner selection and contracting -- from the relative lack of experience of US suppliers in working with Toyota's engineering system; and logistics coordination problems -- inventory, delivery and information sharing -- exacerbated by the communication challenges involving multiple engineering companies and suppliers in Japan and the US.

In summary, significant growth is expected in product innovation in response to industry trends, sustainability concerns and emerging market demand. Recognizing the need to optimize the total return on investment for new product development costs, the supply chain function could be relied upon to reduce the time-to-market of either radical or incremental sustainability-related innovations on existing products, conceivably to achieve higher sales goals or even maintain existing profitability targets. When a company makes a decision about its supply chain, it may have to live with that decision for years and over many product generations [19]. Therefore, it is important to get a cross-functional team from product, process and supply chain involved and working with each other early on in the process. The team must focus on bringing the current product innovation to market, but also must consider the impact of its decisions on future product generations -- in particular, the set of competencies the company will build and maintain after product launch, as well as its dependencies on supply chain partners that result from the choices made for achieving this launch.

In some cases, supply chain managers could also consider partnering with existing Third party Logistics (3PL) networks for advice and professional management in developing their company's capabilities for aftermarket services. 3PL service networks have demonstrated after-market service capabilities in a number of industries upon which companies in Europe can meaningfully build, for example the ability to combine products that have low volume and intermittent demand with innovative high value services through a 3PL partnership.

5.7 Integration

In order to achieve and maintain supply chain cost efficiencies and flexible and agile responses, more deliberate efforts will be made by European managers to develop an environment where integration and close coordination is increased. An equal number of managers across Europe and the US agree that visibility of customer and supplier transaction information along with the use of decision support tools allows for an optimal response by the supply chain as a whole (Figure 5.13). They have also said that it improves performance as measured by forecast accuracy or fill rate. While it is known that integration enables such visibility, improves coordination and avoids local optimizations, which is a competitive advantage for the supply chain as whole, nearly all of the managers who reported having no visibility of supplier transaction information were from Europe.

Therefore, in the future, there will be an increased effort to achieve supply chain integration at European companies. When combined with the trend of relocating operations to low-cost and high-demand emerging markets, the necessity to move towards more integrated and collaborative planning and logistics capabilities will increase.

When asked about the difficulties that they face with achieving such integration, more than half of European managers agreed that the problems were caused by the perception of loss of information and control. More than half view their internal strategic planning process and internal demand planning process as having multiple disconnected

sub-processes and lacking in the use of common technologies. By comparison, they view manufacturing planning, delivery planning, supply planning, and procurement planning as having fewer disconnects. Similarly, more than half of the European managers agreed that the demand planning process with their customers had multiple disconnects, also due to the customer's perception of loss of information and control. Nearly the same number also lacked integration in their procurement planning process with suppliers or in their delivery planning processes with their transportation service providers, for the same reasons.

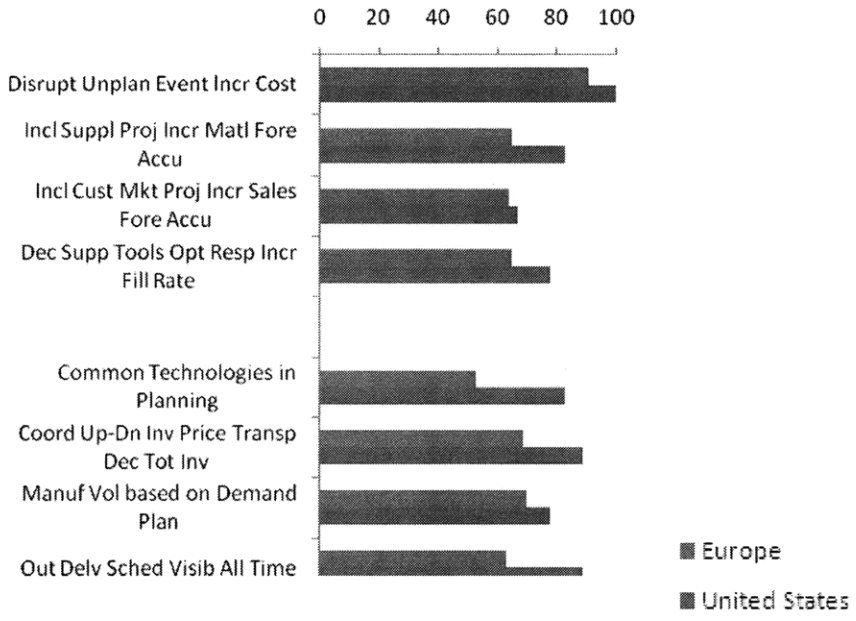

Figure 5.13: Integration assessment- percentage who agree

Nearly half of the European managers also disagree about whether the customer, supplier or distribution center participates in optimizing overall inventory level. While improvements in order fulfillment lead-time, customer responsiveness and cost efficiency are to be expected from integration with suppliers and customers, European companies will continue to be faced with challenges of internal integration. Therefore, in some cases senior management sponsorship will be viewed as necessary to support the well-run sales and operations planning process that is so crucial to creating a best- in- class global supply chain, and could be a major competitive advantage for a company.

At the operational level, it is known that the coordination of supplier and customer inventory policies along with pricing and transportation decisions has the potential to eventually provide inventory reductions by up to 25% [70]. Integration would also provide the ability to run "what-if" scenarios to determine inventory drivers and which pull vs. push strategy could be enabled at each stage. This would lead to increased flexibility because managers could balance response cycle times with optimal inventories. Another example of an area that could drive a growth in integration efforts is the impact of reverse logistics on sustainability measures such as automated tracking during product acquisition, disposition, or product transportation, reconditioning and follow-on distribution and sales. Also, in cases where European companies could leverage local alliances in order to reduce risk in emerging markets, organizational arrangements that complement and support supply chain integration would be preferred. In some instances, integration will be viewed as essential for border and supply chain security from a customs point of view.

It is known that process and system maturity work together for achieving high supply chain performance, measured by lower inventory level, higher fill rate, reduction in cash to cash cycle time, and reduction in obsolescence cost [68.413]. In this referenced study comparing the maturity of the company's business processes with that of its IT systems (Figure 5.14), it is revealed that companies with mature business processes and IT planning practices also showed significant improvement on operational performance (cell C). Companies with mature business processes but immature IT systems showed better profitability with further potential (cell B). Companies with immature business processes but mature IT systems showed significant inefficiencies (cell D). Companies with single site informal and manual planning processes showed below average business performance (cell A).

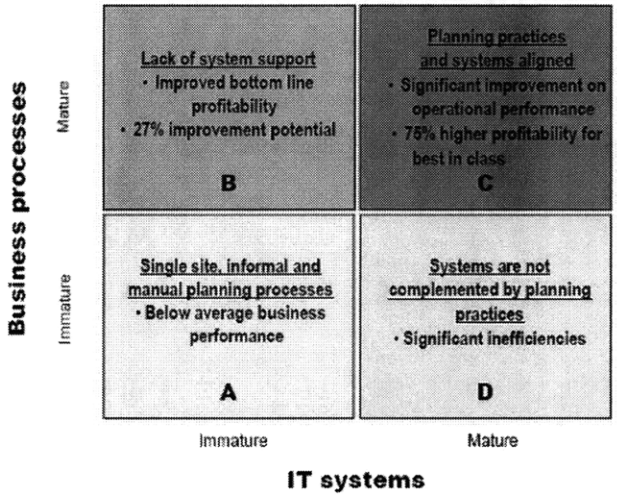

Figure 5.14: Linking processes and systems with operational and financial performance [68.413]

In summary, it is important to take a holistic view of the expected supply chain changes reported in our study. Cross-functional integration within the company and its key partners should focus on achieving maturity in business processes and supporting systems. Without supporting processes to effectively transform the information available through integration into decisions, the supply chain performance may not improve as expected [68. 413].

Typically, supply chain processes are classified in terms of the time horizon that they focus on -- strategic, tactical and operational. Network optimization is a strategic supply chain process, demand planning and supply planning are tactical processes and demand fulfillment and supply chain execution are operational processes. An example of supply chain process and systems enablers is shown below (Figure 5.15). This is one example of a self-diagnostic that companies could undertake, and identify how to go about exploiting the opportunities identified in this study.

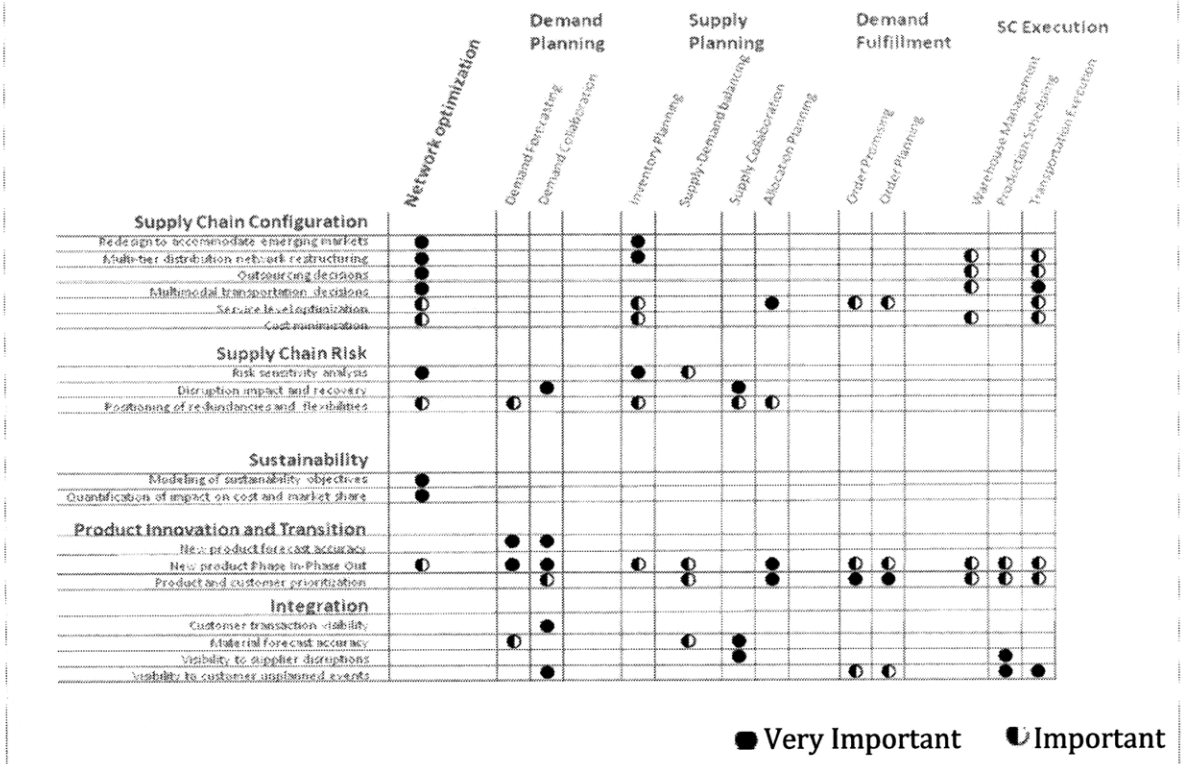

Figure 5.15: Example of supply chain process and system enablers

5.8 Interactions

Supply chain configuration- Markets and Distribution: Survey participants who agreed with a multi tier distribution structure in order to be responsive to emerging market demand were also more likely to agree with lowering operating costs as a supply chain objective. Those who agreed with a possible redesign of the supply chain as a response to emerging market demand were also more likely to agree with the inclusion of carbon emissions in supplier selection criteria (Table 5.1).

Variable 1	Variable 2	p value
emgmktdem	sustmeaslifecycleenergyco2suppse	0.053
multitierdistemgmktcustresp	objcostoper	0

Table 5.1: Supply chain configuration – Markets and Distribution bivariate analysis

Supply chain configuration- Procurement and Manufacturing: Participants who agreed with an increase in emerging market supply were also more likely to agree with competitive differentiation as a supply chain objective and the inclusion of carbon emissions in supplier selection criteria. Those who agreed with including flexibility and speed in supplier selection criteria were more likely to agree with profitability as a supply chain objective and the growing importance of supply chain risk management (Table 5.2).

Variable 1	Variable 2	p value
emgmktsuppl	Objcompdiff	0.003
emgmktsuppl	sustmeaslifecycleenergyco2suppse	0.047
suppselflexspeed	objprofit	0.001
suppselflexspeed	rskgainimp	0.009

Table 5.2: Supply chain configuration – Procurement and Manufacturing bivariate analysis

Supply chain configuration- Transportation: Participants who agreed with having a sustainability related supply chain initiative underway were also more likely to agree that use of multi modal transportation is successful. Those who agreed with including carbon emissions in supplier selection criteria were also more likely to agree with entering into long term logistics service contracts. Also, those who agreed with increasing the use of multi modal transportation were more likely to agree with lowering operating costs as a supply chain objective (Table 5.3).

Variable 1	Variable 2	p value
tptltcontrlogstcsserv	sustmeaslifecycleenergyco2suppse	0.002
tptmultimod	objcostoper	0.009
tptmultimodsucc	sustimplunderway	0.035

Table 5.3: Supply chain configuration – Transportation bivariate analysis

Risk: Participants who agreed that formal assessment of risk is done were also more likely to agree that managing supply chain risk is gaining importance and that supplier performance contracts are being used to mitigate risk (Table 5.4).

Variable 1	Variable 2	p value
gainimp	rskformlassess	0.01
formlassess	rskperfcontrmiti	0.041

Table 5.4: Supply chain risk-bivariate analysis

Sustainability: Survey participants who agreed with having a sustainability related supply chain initiative underway were also more likely to agree with redesigning the supply chain as response to government regulation and including carbon emissions in supplier selection criteria. Those who agreed with redesigning the supply chain as response to government regulation and including carbon emissions in supplier selection criteria were more likely to agree that sustainability related supply chain initiatives increase cost (Table 5.5).

Variable 1	Variable 2	p value
implunderway	sustmeaslifecycleenergyco2suppse	0
implunderway	sustredscresppolicgovreg	0.002
measlifecycleenergyco2suppse	sustimplinccost	0.001
redscresppolicgovreg	sustimplinccost	0.007

Table 5.5: Sustainability- bivariate analysis

Technology: Participants who agreed that inventory optimization technologies provided a rapid return on investment were also more likely to agree that network modeling and optimization provides a rapid return on investment and that information technology solutions that provide a rapid return on investment are favored (Table 5.6).

Variable 1	Variable 2	p value
ntwrkmdloptiprovrapidroi	techinvoptitechprovrapidroi	0
itprovrapidroifav	techinvoptitechprovrapidroi	0.011

Table 5.6: Technology- bivariate analysis

Chapter 6: Conclusions

Supply chain management has driven significant and measurable benefits by minimizing cross-functional conflicts and increasing collaboration with suppliers and customers. However, energy costs, business risks, sustainability measures and emerging economies have placed a new set of pressures on supply chain management. It is quite likely that another adaptation in global supply chains is a real possibility, for companies to be able to continue to lower costs, grow margins, mitigate business risk, and synchronize cash flow with material flow. The key takeaways regarding such an adaptation are as follows:

- Demand from emerging markets, procurement from suppliers in these markets, compliance with sustainability measures, increase in service offerings, and the use of multi modal transportation are the primary engines that will drive new supply chain configurations.
- The commonly identified emerging markets are Eastern Europe, Russia, India and China. More European managers expect an increase in emerging market supply. Russia could also become a viable passage for imported products from Asia Pacific to the European Union, an alternative to sea transport to Western European ports.
- Europe manufacturing and distribution networks will continue to evolve with a faster adoption of alternative forms of transport and DC structures. Decisions to locate new DCs will be based on transport infrastructure maturity, labor costs, proximity to seaports and customers, business environment ease, and level of incentives. With Germany having both well developed road and rail transport infrastructures, a rise in multi-modal transport infrastructures is expected on the borders of Germany; advancing the movement of EDC locations towards Germany.
- Green supply chain initiatives can be a source of competitive differentiation and their lack a competitive disadvantage. This provides an opportunity for the supply chain function to become a key partner of the internal product innovation team, by designing and building in better environmental performance into the products.
- Recognizing the need to optimize the total return on investment for new product development costs, the supply chain function could be relied upon to reduce the

time-to-market of either radical or incremental sustainability-related innovations on existing products, conceivably to achieve higher sales goals or even maintain existing profitability targets.

- Building a picture of the carbon footprint of a product by measuring emissions across the supply chain is a growing trend. It could help supply chain managers identify the largest emission sources across the supply chain and prioritize emission reduction opportunities. In some cases, carbon credits to cover the increase in costs might make the carbon footprint reduction economically sound.
- Sustainability measures may lead to companies streamlining their reverse logistics processes and integrate it using standards for automated tracking during product acquisition and disposition; or reconditioning and follow-on distribution and sales.
- Many EU managers say that involvement of customers and suppliers in product transition planning is limited. The misalignment of component material, technology and product life cycle continues to be seen as an impediment to managing transitions.
- Many European managers view their internal strategic and demand planning processes as having multiple disconnected sub-processes. They also disagree about whether the customers, suppliers or distribution centers participate in optimizing overall inventory level. Future inventory policy points towards gradual introduction of a measured level of flexibility and redundancy to mitigate risks related to lean supply chain models.
- Risk is foremost on the minds of supply chain managers, and many lack corporate standards and practices for a central view of the impact of supply chain risk on the business Supply chain risk management is mostly decentralized and primarily through performance contracts with suppliers and passing cost increases to customers.

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Appendix

A1. Key Themes and Concepts from Literature Review

Research Area	Relevant Aspects	Authors
IT investments	Connection between IT investments, business process maturity and business performance.	Heinrich, Simchi-Levi(2005)
Supply Chain progress	Functions included, costs included, spending, technologies employed, development areas, vulnerabilities and future investments.	CSC, SCMR(2004)
Europe trends	Priorities, spending, percentage of companies at stage 3 and 4 and industry-level issues.	PRTM(2007)
Europe topics	Supply chain planning vs. execution, risk perspectives, metrics, customs, regulations, freight invoice verification and security.	SCC Brussels(2007)
Europe 3PL	Business processes, trends, gaps, opportunities, comparison of Europe vs. US, continuing problems and current and future use of technology.	CG, Georgia Tech(2007)
Europe distribution	EU enlargement impact, location decision criteria, transport infrastructure, incentives, proximity to customers, labor costs and Eastern Europe.	CG(2003)
Europe integration	European survey of inter-firm integration, IT integration and performance. Areas such as feedback-seeking, decision making, relationships and systems.	Bagchi, Ha, Skjoett-Larsen(2005)
Europe challenges	Variations in accessibility and costs, regional specializations, coordination of operations and collaborative capabilities.	Findlay
Europe segmentation	Factors influencing supply chain segmentation and total cost reduction. An example of Sony Europe.	Lovell, Saw(2005)

Europe RFID	Inhibitors and drivers of European RFID adoption	Gartner(2006)
Europe logistics	Market segmentation by geography, value and forecast for the Europe logistics market with $150.1 billion in 2006 revenue and CAGR of 2%.	Datamonitor(2007)
Europe warehouse	Growing importance of centralized, adaptable and optimization of end-to-end SCE. Vendors to demonstrate new technology, multi-lingual and customs.	Gartner(2007)
Europe challenges	Demand side focus to improve on time delivery and responsiveness. Supply side to extend Lean principles to partners. Data is a key barrier.	Ross(2006)
Europe supply network	Key emerging trends in outsourcing, data visibility, life cycle management, responsiveness and technology.	IBM(2005)
Nordic Telecom	Adverse impact and imminent threats of global trends on Nordic telecom suppliers.	Handelsbanken(2007)
Post-Soviet	Hypotheses (supported and unsupported) for logistics management by European and North American companies in Kazakhstan's context.	Price(2006)
Integration	Propositions regarding technology and organizational integration and current state evaluation.	Bagchi, Skjoett-Larsen(2003)
Integration	Interaction, pitfalls and gains of internal and downstream integration on performance.	Germain, Iyer(2006)
Inventory	Priority differentiation strategy and optimal production and inventory policies.	Duran, Liu, Simchi-Levi(2007)
Inventory	Optimal designed push-pull strategy and positioning inventory across the supply chain for most value with the least amount .	Simchi-Levi(2004)
Inventory	Inventory placement in a network based on an optimal combination of service delivery, safety stock and total cost.	Magnanti, Shen, Shu, Simchi-Levi(2005)

Inventory	Inventory policy that maximizes average profit when pricing and inventory decisions are made simultaneously.	Chen, Simchi-Levi
Inventory	Incorporating risk aversion into inventory and pricing models.	Chen, Sim, Simchi-Levi(2007)
Inventory	Customer response through the sales and production effects and impact on capacity utilization policies.	Goncalves(2006)
Inventory	Order splitting as an interim tactic to cope with a composite set of extreme conditions such as exceptionally high lead-time volatility and demand.	Thomas, Tyworth(2007)
Risk	Potential supply chain risks, mitigation actions, standards and capabilities.	McKinsey(2006)
Risk	Resilience, quick recovery and minimizing impact of disruption on long-term performance.	Sheffi(2005)
Coordination	Propositions for price, non-price and flow coordination mechanisms.	Fugate, Sahin(2006)
Procurement	Portfolio contract as a combination of traditional contracts such as long-term, options and flexibility for reducing price and inventory risks.	Martinez-de-Albeniz, Simchi-Levi(2005)
Procurement	Combination of innovative bidding, online supplier negotiations and scenario-based optimization analysis, for a global procurement strategy .	Metty, Harlan(2005)
Supplier	Underlying dimensions of supplier selection – US vs. Europe	Hsu, Kannan(2006)
Supplier	Approach to supplier performance with a view that buyer and supplier outcomes are co-dependent on the coordinated actions of both.	Ross, Buffa(2006)
Supply	Risk management strategies for contracts, buyer's perspective where risk is measured as variance in profits.	Martinez-de-Albeniz, Simchi-Levi(2006)

Transportation	Optimization based procurement strategy and process for transportation services.	Caplice, Sheffi(2003)
Transportation	Trailer leasing market and case study.	Van Ryzin(1998)
Product Development	Timing and implications of logistics involvement in new product development.	Zacharia, Mentzer(2007)
New Products	Supply chain configuration to choose an optimal option at each stage such that the total cost – COGS, safety and pipeline stock is minimized.	Graves, Willems
Innovation	Logistics innovation process- customer clue gathering activities, clarifying activities, inter-organizational learning and setting the stage activities	Flint, Larsson, Gammelgaard(2005)
Process frameworks	Evaluation of SCOR and GSCF frameworks-scope and processes.	Lambert, Garcia-Dastugue, (2007)
Supply Chain planning	Emerging areas and technologies in the bifurcating process automation and process innovation markets.	Gartner(2006)
Performance	Alignment of performance measures with information reporting needs, in the measurement space of competitive bias, measurement focus and frequency.	Griffis, Goldsby(2007)
Performance	Focusing operational performance measurement system on the right things	Hammer(2007)
RFID	Areas of supply chain operations impacted by automatic identification, technological and organizational challenges.	McFarlane, Sheffi(2003)
Pipelines	Strategies for the seven discrete pipelines: pure standardization, compressed life cycle, compressed time-to-market, mass customization via assembly, logistics postponement, mass customization via processing and pure customization.	Aitken, Childerhouse, Martin(2005)
Postponement	Inter-organizational time based postponement	Garcia-Dastugue, Lambert(2007)

Loyalty	Propositions for loyalty drivers based on credibility, dependability, transferability and confirm ability.	Davis, Mentzer(2006)
Strategy	Agility, Adaptability and Alignment in supply chains provide sustainable competitive advantage.	Lee(2004)
Strategy	Focus, Architecture, and Technology: Architecture link that aligns product and supply chain architectures. Technology link encompasses the coordination of detailed product designs with process capabilities. Focus decisions link choices about the manufacturing system design with those in logistics and materials system design.	Fine(1998)
Strategy	Portfolio approach to merchandising with specific intents and processes for allocating resources based on category for inventory efficiency.	Barney(2005)

Appendix

A2. List of sources

1. ASCET
2. Booz Allen Hamilton
3. Carbon Trust
4. Clockspeed
5. Cap Gemini
6. CSC
7. Data Monitor
8. Designing and Managing the Supply Chain
9. Gartner
10. Georgia Tech
11. Handelsbanken
12. Harvard Business Review
13. IIE Transactions
14. Inbound Logistics
15. Informs
16. International Journal of Logistics
17. Journal of Business Logistics
18. Manufacturing Insights
19. McKinsey
20. Naval Research Logistics
21. Operations Research Letters
22. Production and Operations Management
23. PRTM
24. Sloan Management Review
25. Supply Chain Council
26. Supply Chain Management Review
27. Understanding Supply Chains
28. World Wide Web

Appendix

A3. Sample survey

Dear Participant,

In recent years, supply chain management has been the focus of executive meetings, business columns and research institutes as never before. Complementing this focus is a substantial growth in investments focused on improving supply chain performance. Our goal in this study is to understand the emergent opportunities and challenges in the management and performance of supply chains.

Your participation in this study is highly valued and appreciated. Please note that,

1. Your company or personnel names will not be linked to any answers. For analysis purposes we will assign a tracking number to each questionnaire indicating the industry and supply chain focus of the answer. All answers from a cohort will be aggregated and the research study will focus on summary statistics. If we use comparison data, the data will be disguised and company identity will not be revealed.

2. Please complete the entire questionnaire within two weeks of receiving it. If you are uncertain about your answer to a question, select your best opinion and continue to the next question.

If you need additional clarification or have any further questions, please do not hesitate to contact Mohit Puri or Costas Vassiliadis.

Sincerely,
Supply Chain Research Team
Room 1-176 Massachusetts Institute of Technology
77 Massachusetts Avenue, Cambridge, Massachusetts
02139-4307 USA

Participant

1. Name

2. Company's Name

3. Current Position/Title

The answers that you provide to all the following questions should be about your company's most important supply chain, as identified by a product, product line or business unit.

4. Briefly describe the product, product line or business unit that you have identified as your company's important supply chain.

For the following questions, please check all the answers that would apply to the supply chain identified above.

5. The supply chain strategy is best described as
a. Cost efficient
b. Flexible response

6. This industry is best described as
a. Consumer
b. High Technology
c. Industrial
d. Retail
e. Transportation
f. Healthcare
g. Services
h. Other_____

7. The primary geographic scope of this operation is
a. Western Europe
b. Eastern Europe
c. North America
d. South America
e. Japan
f. Asia
g. Middle East
h. Africa
i. Other _____

8. The type of this supply chain is
a. Manufacturing: __ Make to Order __ Make to Stock __ Assemble to Order __ Process __ Discrete
b. Wholesale
c. Distributor
d. Retail
e. 3PL provider
f. Service
g. Other _____

On a scale of 1 to 5, please circle your assessment of the supply chain identified above.

		Strongly Disagree		*Neutral*		*Agree Strongly Agree*
Objectives and Metrics						
9.	Supply chain is a competitive differentiator for this business	1	2	3	4	5
10.	Supply chain objectives exist to increase market share	1	2	3	4	5
11.	Supply chain objectives exist to increase profitability	1	2	3	4	5
12.	Supply chain objectives exist to decrease operating costs	1	2	3	4	5
13.	Inventory is being managed to match the full life cycle of product lines	1	2	3	4	5
14.	Service level is established and monitored for different market segments	1	2	3	4	5
15.	Supply chain redundancies exist for quick recovery from disruptions	1	2	3	4	5
16.	Supply chain flexibilities exists for quick recovery from disruptions	1	2	3	4	5

17. Under the column heading 'Value' please provide the average annual estimate for each metric. You could indicate 'Not applicable' for metrics that are not being used for the supply chain identified above. Please use the blank rows to provide any additional metrics being used for this supply chain that were not listed in the table below.

#	Value	Metric	Description of Measurement Unit
a		Total Sales Revenue	Please circle one: Euros US Dollars
b		Total Cost of Goods Sold	Please circle one: Euros US Dollars
c		Average Unit Price	Please circle one: Euros US Dollars
d		Market Share	% of Target Customer Market Control
e		New Product Sales Revenue	% of Sales Revenue from Products < 3 years old
f		Cash-to-Cash	Accounts Payable to Receivable Cycle time in Days
g		Customer Satisfaction Index	Normalized Score
h		Customer Order Fulfillment	Lead-time in Days from Order to Delivery
i		Customer Order Fill Rate (Value)	% of Customer Order Value delivered on-time
j		Customer Order Fill Rate (Quantity)	% of Customer Order Quantity delivered on-time
k		Forecast Accuracy	% of Sales Revenue
l		Inventory	Days of Sales Revenue

18. Please list the four most important supply chain objectives of the supply chain identified above.

19. Please list the four most important metrics for the supply chain identified above.

Supply Chain Configuration

Markets and Distribution

20.	Redesigning the supply chain is needed to fulfill demand from customers in emerging markets	1	2	3	4	5
21.	Implementing a multi-tiered distribution structure is needed for responsiveness to customers in emerging markets	1	2	3	4	5
22.	Redesigning the distribution network would alleviate difficulties due to transportation congestion	1	2	3	4	5
23.	Redesigning the distribution network in response to the favorable policies of governments in emerging markets, could be expected	1	2	3	4	5
24.	Relocating own distribution center operations to emerging markets for a cost effective global supply chain, could be expected	1	2	3	4	5
25.	Outsourcing the distribution center operation to supply chain partners would allow benefits such as competitive cost, better service or access to specialized services	1	2	3	4	5
26.	Outsourcing of distribution center operations is successful	1	2	3	4	5

Procurement and Manufacturing

27.	Redesigning the supply chain is needed to procure from suppliers in emerging markets	1	2	3	4	5
28.	Supplier selection is based on flexibility and speed of response to change	1	2	3	4	5
29.	Supply contracts are effective in reducing cost	1	2	3	4	5
30.	Supply contracts are effective in ensuring adequate supply	1	2	3	4	5
31.	Redesigning the manufacturing network is needed for proximity to suppliers in emerging markets	1	2	3	4	5
32.	Redesigning the manufacturing network in response to the favorable policies of governments in emerging markets, could be expected	1	2	3	4	5
33.	Relocating own manufacturing operations to emerging markets for a cost effective global supply chain, could be expected	1	2	3	4	5
34.	Outsourcing the manufacturing operation to supply chain partners in emerging markets would allow for benefits such as competitive cost, better service or specialized know-how	1	2	3	4	5
35.	Outsourcing of manufacturing operations is successful	1	2	3	4	5

Transportation

36.	Increasing use of multimodal transportation strategy could be expected (such as a combination of road, rail, water or air transportation)	1	2	3	4	5
37.	Multimodal transportation strategy is successful	1	2	3	4	5
38.	Buying power for transportation services is weak	1	2	3	4	5
39.	Entering long term contracts with integrated logistics service providers could be expected	1	2	3	4	5
40.	Considering service-price trade-offs when analyzing transportation bids could be expected	1	2	3	4	5

41. Please list the four most important changes in the future, for the supply chain identified above.

42. Please list the four most important emerging markets, for the supply chain identified above.

Risk

43.	Supply chain risk management is gaining importance	1	2	3	4	5
44.	Formal assessment of supply chain risks is being done	1	2	3	4	5
45.	Corporate standards or practices for supply chain risk management exist	1	2	3	4	5
46.	Central view of supply chain risks exists	1	2	3	4	5
47.	Supply chain risk is managed centrally	1	2	3	4	5
48.	Performance contracts with partners are being used to mitigate supply chain risks	1	2	3	4	5
49.	Redundancy is being used to mitigate supply chain risks	1	2	3	4	5
50.	Vertical integration is being used to mitigate supply chain risks	1	2	3	4	5
51.	Diversification strategies are being used to mitigate supply chain risks	1	2	3	4	5
52.	Financial hedging instruments are being used to mitigate supply chain risks	1	2	3	4	5

Sustainability

53.	Implementation of sustainability or 'green' supply chain initiatives, is currently underway	1	2	3	4	5

54.	Redesigning the supply chain in response to sustainability policies and government regulations , could be expected	1	2	3	4	5
55.	Development of new ' green' supply chains could be relatively easier than updating existing supply chain to 'green' criteria	1	2	3	4	5
56.	Measures for full life cycle energy and carbon foot print could be included in the supplier selection criteria	1	2	3	4	5
57.	Measures for full life cycle energy and carbon foot print could be a competitive differentiator	1	2	3	4	5
58.	Common criteria are needed to determine how 'green' a product or supplier is	1	2	3	4	5
59.	Implementation of sustainability or 'green' supply chain initiatives, could increase supply chain costs	1	2	3	4	5
60.	Implementation of sustainability or 'green' supply chain initiatives, could increase market share	1	2	3	4	5

Product Innovation

61.	Product innovation is a growing trend	1	2	3	4	5
62.	Focus on synchronization of product innovation across the supply chain is gaining importance	1	2	3	4	5
63.	Product innovation team includes internal supply chain representatives	1	2	3	4	5
64.	Product innovation process includes external supplier representatives	1	2	3	4	5
65.	Product innovation process includes external customer representatives	1	2	3	4	5
66.	Modularity in product innovation is encouraged to improve supply chain synchronization	1	2	3	4	5
67.	Product transitions is a growing trend	1	2	3	4	5
68.	Focus on synchronization of product transitions across the supply chain is gaining importance	1	2	3	4	5
69.	Companies with successful product innovation and product transition track record have more influential and leadership roles in collaborative supply chain processes	1	2	3	4	5

Integration - Downstream

70.	Market projections from customers is included in the sales forecast	1	2	3	4	5

71.	The use of market projections from customers, increases sales forecast accuracy	1	2	3	4	5
72.	Supply chain disruption due to unplanned customer events increases costs	1	2	3	4	5
73.	Transaction information from customers is consistently visible (such as customer inventory situation or point of sale data)	1	2	3	4	5
74.	The use of transaction information from customers minimizes supply chain disruption	1	2	3	4	5
75.	Decision support tools are used for an optimal response to unplanned customer events	1	2	3	4	5
76.	The use of decision support tools increases service level from customer's perspective	1	2	3	4	5

Integration - Upstream

77.	Projections from suppliers is included in the material forecast	1	2	3	4	5
78.	The use of projections from suppliers increases material forecast	1	2	3	4	5
79.	Supply chain disruption due to unplanned supplier events increases costs	1	2	3	4	5
80.	Transaction information from suppliers is consistently visible (such as supplier inventory situation, delivery schedule or work in process)	1	2	3	4	5
81.	The use of transaction information from suppliers minimizes supply chain disruption	1	2	3	4	5
82.	Decision support tools are used for an optimal response to unplanned supplier events	1	2	3	4	5

Integration - Internal difficulties

83.	Internally, the strategic planning activity consists of multiple disconnected processes	1	2	3	4	5
84.	Internally, the demand planning activity consists of multiple disconnected processes	1	2	3	4	5
85.	Internally, the supply planning activity consists of multiple disconnected processes	1	2	3	4	5
86.	Internally, the supply-demand balancing activity consists of multiple disconnected processes	1	2	3	4	5

87.	Internally, the procurement planning activity consists of multiple disconnected processes	1	2	3	4	5
88.	Internally, the manufacturing planning activity consists of multiple disconnected processes	1	2	3	4	5
89.	Internally, the delivery planning activity consists of multiple disconnected processes	1	2	3	4	5
90.	Internally, common technologies are in use across the above supply chain planning activities	1	2	3	4	5
91.	Internally, lack of integration in some of the above supply chain planning activities could be due to perceived loss of information and control	1	2	3	4	5

Integration - External difficulties

92.	Externally with customers, the demand planning activity consists of multiple disconnected processes	1	2	3	4	5
93.	Externally with customers, common technologies are in use for demand planning activities	1	2	3	4	5
94.	Externally with customers, lack of integration in the demand planning activity could be due to the customer's perceived loss of Information and control	1	2	3	4	5
95.	Externally with suppliers, the procurement planning activity consists of multiple disconnected processes	1	2	3	4	5
96.	Externally with suppliers, common technologies are in use for procurement planning activities	1	2	3	4	5
97.	Externally with suppliers, lack of integration of the procurement planning activity could be due to the supplier's perceived loss of information and control	1	2	3	4	5
98.	Externally with the transportation partners, the delivery planning activity consists of multiple disconnected processes	1	2	3	4	5
99.	Externally with the transportation partners, common technologies are in use for delivery planning activities	1	2	3	4	5

Data

100.	Data integrity is high across the supply chain	1	2	3	4	5
101.	Event alerts are consistently available across the supply chain	1	2	3	4	5
102.	Delivery schedule is visible at all times	1	2	3	4	5

103.	Overall inventory is monitored to match the demand plan	1	2	3	4	5
104.	Manufacturing volume is determined based on the demand plan	1	2	3	4	5
105.	Manufacturing participates in optimizing overall inventory levels	1	2	3	4	5
106.	Supply schedule for manufacturing is adjusted based on event alerts	1	2	3	4	5
107.	Procurement volume is determined based on the demand plan	1	2	3	4	5
108.	Supply schedule for procurement is adjusted based on event alerts	1	2	3	4	5
109.	Suppliers participate in optimizing overall inventory levels	1	2	3	4	5
110.	Distribution center participates in optimizing overall inventory levels	1	2	3	4	5
111.	Customers participate in optimizing overall inventory levels	1	2	3	4	5

Information Technology

112.	IT solutions with a proven and rapid return-on-investment are favored	1	2	3	4	5
113.	Supply chain network modeling and optimization has a proven and rapid return-on-investment	1	2	3	4	5
114.	Inventory optimization technologies have a proven and rapid-return-on-investment	1	2	3	4	5
115.	RFID challenges in storage and access of large data volumes, accuracy, interference or cost, impede its adoption	1	2	3	4	5
116.	RFID benefits such as variability management from shortage, lateness, or errors are important for high supply chain performance	1	2	3	4	5

Thank you for your time.

Appendix

A4. Sample STATA Command File

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