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## A TAXONOMY OF LOGISTICS INNOVATIONS

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**Abstract – In this paper we present a taxonomy of supply chain and logistics innovations, which is based on an extensive literature survey. Our primary goal is to provide guidelines for choosing the most appropriate innovations for a company, such that the company can outrun its competitors. We investigate the factors, both internal and external to the company, that determine the applicability and effectiveness of the listed innovations. We support our suggestions with real world cases reported in literature.**

**Keywords – Supply Chain Innovations, Logistics Innovations, Supply Chain Trends**

## Introduction

As the global competition gets deeper and wider; companies have to find different ways to keep up with the competition. The ways companies use may differ; however, the only goal is to *survive* in the harsh conditions of the global market. Survival depends on how robust the companies are against the changes of trends, and diverse situations. Therefore, companies must be adopting themselves to the limitless changes of the environment they exist in, which is –in our time- the entire world. A supply chain with suitable attributes brings many advantages to the companies that are involved in it in this aspect. Improving the supply chain with some tools makes it possible to adopt the changes of the market into the supply chain organization. In order to have strong competitive capabilities in the market, all the units of organizations must be innovative. Each of these units in the supply chain must make proper innovations to work more efficiently. This situation brings about the concept of *supply chain innovation*, which covers all the innovative activities that aim the better operation of the whole supply chain and to gain competitive advantage.

In this study we concentrate on the supply chain and logistic innovations as a whole and construct a *taxonomy of supply chain innovations*. The essential objective is to motivate firms to make proper innovations in their supply chains according to their desired goals and supply chains' specialities. By making the correct innovations, firms can gain better competitive advantage. In order to determine supply chain innovations in a systematic manner, this paper suggests taxonomy according to the previous research on supply chain innovations and case studies. As for the methodology of the supply chain innovation taxonomy, various elements are used such as technology, knowledge, relationship networks, decision phases and extent of change by the help of innovation. In addition, firms are classified according to their supply chain attributes, supply chain innovation tools and goals of these innovations. In relation with the objective mentioned above and using the taxonomy at hand, this research eventually aims to answer the following question: "What kind of supply chains can have what kind of innovations, to accomplish what kind of goals?" An answer to this question can be obtained with real world case studies that can be regarded as guidance. After detailed analysis of real world case studies, some recommendations can be made to the firms that plan to make supply chain innovations.

## **Supply Chain Innovation**

Supply chain strategy is vital for the firms to gain competitive advantages in the fast-growing market. Inside the supply chain activities, lots of different processes are included such as products, information and cash flows which are required to work collaboratively and share among different entities of supply chain (Chopra, 2007). The main objective of a company is to make its products or services available to its customers with minimum cost and highest market value. The organization of its supply chain plays the leading role in achieving this goal since it is directly related with the time, quantity, specification and price at which the end customer reaches the product or service (Levi and Kaminsky, 2003). In case of a change in the market conditions, the appropriate innovations depending on the supply chain structure can be useful in order to adapt to these new conditions. While innovations were mostly based on the improvement of the manufacturing strategies in the past, today they are also implemented in the other activities such as distribution, marketing, storage and any other areas included in the supply chain. Since the supply chain consists of everything starting from the raw material procurement and going through until the product reaches to the end user, the innovations have especially become more vital for the supply chain in order to get a competitive advantage. It is possible to claim that the companies which give importance to the supply chain innovations gain vast competitive advantages in their market and become the leader in the industry.

## **Literature Overview**

Being a highly popular concept in today's business world, innovation is heavily investigated in the literature in terms of many aspects: the methods, the reasons, the tools etc. In his book *Mastering the Dynamics of Innovation*, Utterback (1996) states that, adopting the initial product to demand deviations and market opportunities by a systematic methodology of innovation carries companies to the leadership in being the most stable to changes. He also emphasises the use of technology for competitive advantage and introduces the concept of *innovation management*. Feldman (2002) points at the innovation's dependence on knowledge and claims that product innovations gather technologic and scientific knowledge with market knowledge. He also introduces the linear model of innovation in which scientific discovery, product development and market introduction precede each other. Acs and Audretsch (1990) investigate innovation in small and big firms' aspect: they compare

the concentration of innovation with the characteristics of industries by the scale of firms. Innovation output is analyzed in small and big firms of highly competitive industries. They concluded that small and large scaled firms respond differently to the change of market conditions. In recent years innovation has turned out to be the main focus of governments as well as firms, there are many studies on governments' innovation structures, and they recommend new models for them. For further information, we refer the reader OECD's Oslo Manual (1995).

In this study, we try to focus on new supply chain strategies and supply chains' relations with new business models and innovation. The papers about supply chains mainly focus on market orientation and customer focused structures. In her paper, Harland introduces different business situations, and offers supply network structures to provide the efficient work of the firms. The paper states some real-world cases such as Benetton, Toyota and Nissan and gives insights about their supply chain strategies (Harland *et al.*, 2001). Another study focuses on the international food supply chain system, system analysis procedures have been applied to two international supply chains in Africa. The paper mainly focuses on spill-over effect on supply chains (Trinekens *et al.*, 2003). An industrial study came from Ohba *et al.* which focuses on the logistics in the film manufacturing industry (Ohba *et al.*, 2000). This paper focuses on the logistic operations in the manufacturing system; and measures the performance of their newly constructed system. The paper of Treville converts supply chain into the demand chain concept (Treville, 2004). The paper focuses on a Nordic pulp and paper manufacturer's supply chain management case. The aim is to provide lead time reduction and sufficient information flow through the supply chain and the paper concludes with theoretical insights. Another study came from Beamon, which focuses on the modelling of the supply chains; the paper gives detailed information about the supply chain models in the literature and gives supply chain performance measures in different papers (Beamon, 1998). Richey focuses on the relationship between reverse logistics and innovation in supply chain (Richey, 2005). The paper makes its analysis in the strategic and operational level. The paper supports its model by making statistical tests. Another paper written by Chapman and Soosay again states the ability of supply chain models to improve competitiveness; it also emphasises the construction of a supply chain model that continuously supports innovative operations (Chapman, Soosay, 2002). One other issue in this paper is the use of technology. The claim is that efficiency and effectiveness growth come with the implementation of new technologies; technology also enables firms to improve their services. The paper gives information about the information flow in the supply chain, and the learning of suppliers

from customers and customers from suppliers. The paper claims that every bit in the supply chain should have an innovative structure.

In addition to these studies, there are many studies related to the taxonomy of supply chains. A new solution method has been offered by Chandra and Tumanyan (2005), their work focuses on the generalization of problems in the supply chains; and by this generalization, the paper constructs a model that carries the knowledge based on the supply chain problems and the taxonomy method is used. Another study of the authors introduces the taxonomy of supply chains; their work relies on systems theory and taxonomy research. Capar *et al.* (2004) introduce a *supply chain management taxonomy* by investigating the supply chain management literature. The paper gives a highly detailed taxonomy structure with exact definitions; we used their taxonomic structure in our supply chain attribution framework. Similar to this study, Hamber (2000) focuses on tactical distribution strategies in the combat area; logistics is also a naval issue and there are many studies related to the logistics among forces of the military service operations. The paper makes a detailed analysis of the distribution operations and reaches to a classification of them. The paper also tries to visualize the outcomes. Another paper is about online distribution. It constructs the taxonomy of channel structures (Clemons and Aron, 2002). The paper determines the parameters for ideal channel structure and analyses each one of them, then reaches a taxonomy based on this information. A taxonomy of information technologies services has been presented by Stern and Davis (2003). The paper takes information technology models as service models and compares the features of these service models, and reaches a taxonomy out of this analysis.

## **Methodology**

Our approach to the construction of the taxonomy of supply chain innovations mainly consists of three aspects. These aspects help us determine the classification of supply chain innovations. It should be remembered that the question we ask is “which sort of supply chains are capable of or needed to make what kind of innovations to achieve what kind of goals?”, therefore we first tried to determine how supply chains differ from each other. We analyzed different case studies and taxonomy papers (Capar *et al.*, 2003) to determine the parameters of supply chains. After that, innovation classification was the case. Our goal was to determine the parameters that define different innovations. Lastly, we listed the goals the firms try to reach when they make supply chain

innovations. Upon combining these three stages together to form a matrix, we are able to answer the question given above. Unless otherwise stated, all current financial data are provided by the Forbes.com.

### ***Determining Supply Chain Attributes***

There are three main categories in supply chain attributes:

- Market attributes
- Supply chain attributes
- Product attributes.

The first category includes the competitive structure which has three subcategories: the market structure of the supply chain can be monopolistic, including only one firm serving in the corresponding market; oligopolistic, which means that there are a few firms serving to the large portion of the customers; and highly competitive – many firms serving many customers, and the customers do not have any loyalty. Number of companies competing in the market and the share of these companies in the total market capitalization determine the competitiveness structure of the market. The second subcategory in the market attributes is related to the size of the service market. This is categorized as a large markets (i.e. total market capitalization is larger than \$ 200 B), medium markets (i.e. total market capitalization is larger than \$ 20 B but less than \$ 200 B) and small markets (i.e. total market capitalization less than \$20 B). The last category in market attributes is the market profitability. This parameter is a strong determinant of the supply chain structure of a firm. High profitability (i.e. more than % 10), medium profitability (i.e. between % 5 and % 10) and low profitability (i.e. less than % 5) are the subcategories of this parameter.

The second category includes the supply chain attributes itself. There are three subcategories under supply chain attributes. The first one is the scale of the supply chain. This parameter varies whether the firm is a local or a global company; so the subcategories are local and global. The second subcategory is the inventory turnover which measures the number of times invested in goods to be sold over in a year. It is clear that companies spend less on holding of items to be sold by increasing the inventory turnover. Inventory turnover ratios of the companies are classified as high and low,

representing the ratios with more than or equal to 7 and less than 7, respectively. The third subcategory is the focus of the supply chain which can be either efficiency or agility. It is possible to claim that if a company produces products that are sold in high amounts to large public, efficiency is the priority of the supply chain. On the other hand if the price is not the primary concern for the consumers and the speedy delivery or availability is much more appreciated, supply chain planners focus on the agility. Number of days Cost of Goods Sold (CGS) in inventory is the fourth subcategory. It is the average inventory from the last two balance sheets divided by the per day cost of goods (i.e. the annual cost of goods divided by 360). Companies are classified under two groups according to their number of days CGS in inventory: high and low, representing the greater or equal to 50 and less than 50, respectively.

The third category is the product attributes of the supply chain. This attributes has eight parameters. First is the life cycle of the product, the product of the supply chain can be any of the four stages: introductory, growth, maturity and decline. Therefore, the supply chain attributes and directly the strategy and the innovations may differ according to which phase the product or service is in. Second parameter is the marketing life length, which can be long or short. For instance, marketing life length of a newly introduced cell phone is shorter than a soft drink. Third parameter is the shelf life of the product. It is also classified as long and short depending on the time passed for a product to become unusable. Fourth parameter is the demand structure. This parameter highly affects the supply chain structure, because the supply chain is constructed according to deliveries. This parameter has three sub categories which are: certain demand with few fluctuations, uncertain demand and project type ordering. Fifth parameter in product attributes is the customer structure, customer attributes are determinants of firms' delivery systems. There are three categories: companies, individual consumers and both or them. The sixth parameter is the manufacturing or service attributes. First subcategory is the order cost: it can be high or low -this is a relative score of course and varies according to the sophistication of the product and the sales channels-, second is the inventory holding cost which can subjectively be high or low. For instance, if a product has a high opportunity cost or some characteristics that can be easily obsolete, it can be considered with high inventory cost. The third subcategory is the transportation costs, higher the transportation is, more critical your supply chain is. While categorizing the companies according to the transportation cost, we take into account the transportation cost as a fraction of the total end value of the product. For instance, transportation cost for packaged food is higher than a complex industrial machine due to the high price of the latter. The seventh parameter of product attributes is the profit structure which has been classified as high and

low. The profit margin of 10 % is taken as a threshold level. High and low subcategories refer to greater and less than this level, respectively. The eighth parameter is specifications. Under specifications, there are four subcategories: durable goods (cars, electronic equipments, and furniture), perishable goods (foods), shopping goods and raw materials (products of the suppliers).

Mind mapping of supply chain attributes may facilitate the understanding of supply chain attributes taxonomy by summarizing in a visual manner. The mind map is given in Figure 1.



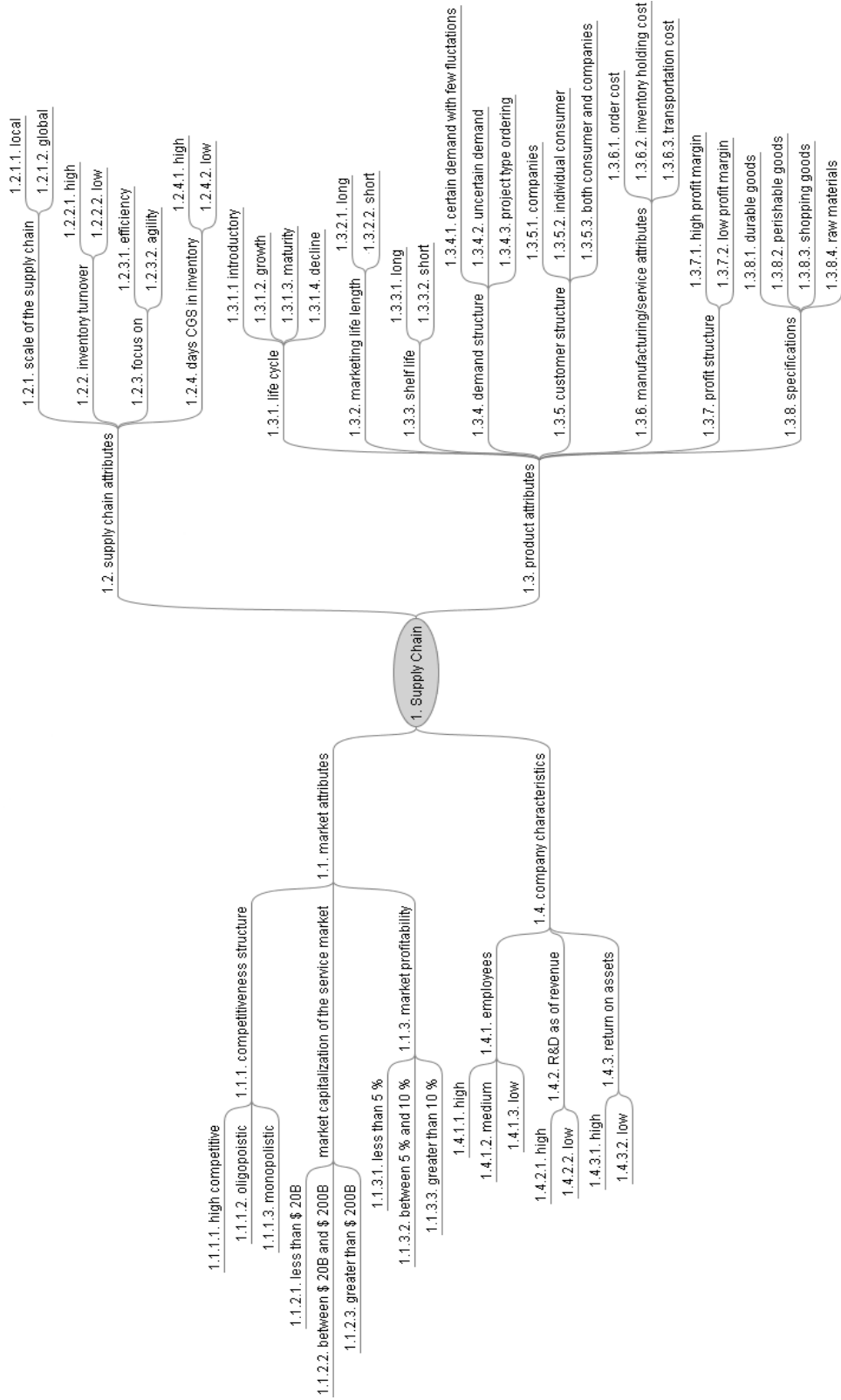


Figure 1. Mind mapping for supply chain attributes

## ***Determining Innovation Attributes***

The attributes of innovations can be categorized depending on various parameters such as where the innovations are done, which tools are used for the innovations, at which decision phase and supply chain stage these innovations are done and the extent of change owing to these innovations.

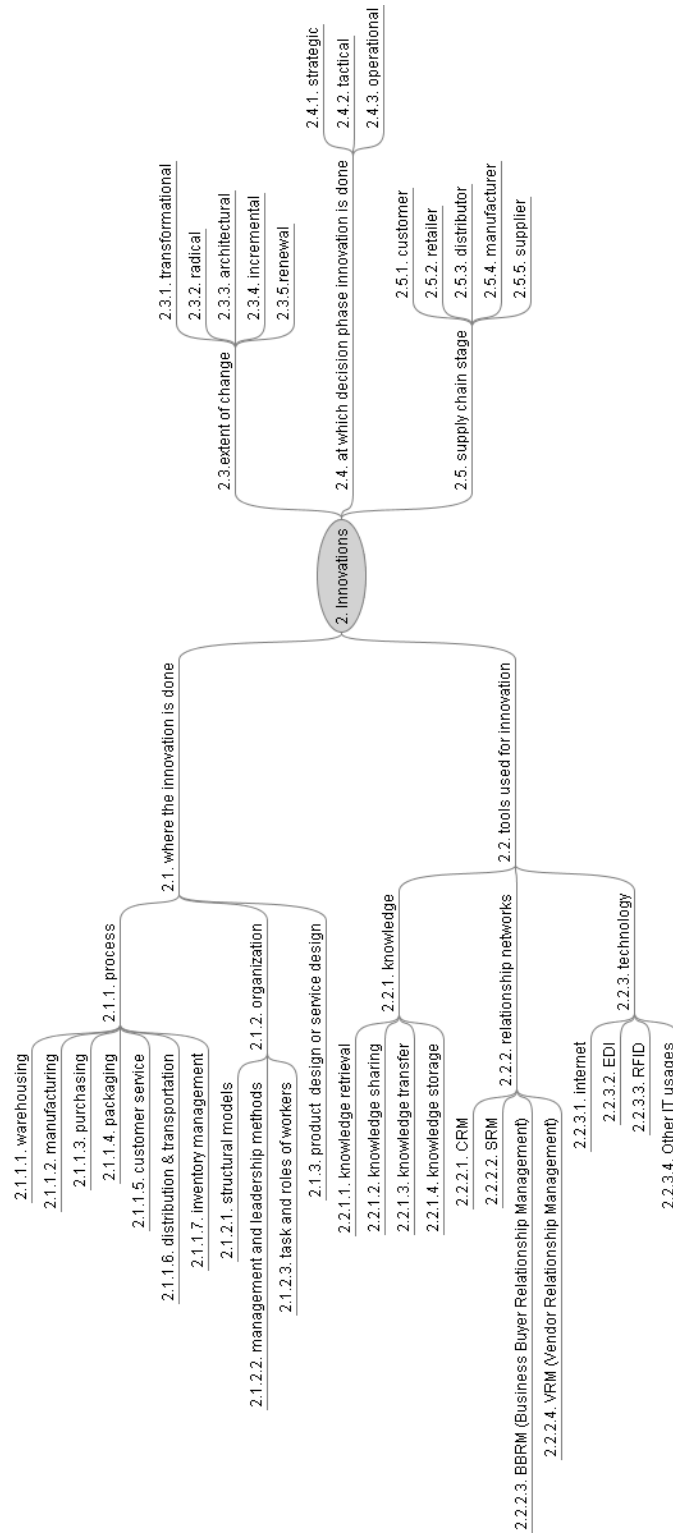
First, companies should determine which supply chain entities to innovate. These entities can be process, organization, and product or service design. If the firm decides to focus on the processes while implementing innovations, it has to define clearly which processes must be improved such as warehousing, manufacturing, purchasing, packaging, customer service, distribution – transportation and inventory management policy. The innovations related to each of these processes require different know-how and have different results for the supply chain partners. If the company wants its innovations to highlight the structure of the organization, the alterations in the structural models, management and leadership methods, tasks and roles of workers become highly important for this firm. Alternatively, the innovations can be done in the design of the products or processes to receive higher quality and better performance.

After deciding on where the innovations will be done, companies should also determine which tools they will use for these innovations. If the innovations are knowledge-based, different methods such as knowledge retrieval, knowledge sharing, knowledge transfer or knowledge storage will be evaluated by the company and the most appropriate one(s) will be selected to be used in the innovations. If the firm gives high importance to the relationship networks, it can use CRM, SRM, Business Buyer Relationship Management (BBRM) or Vendor Relationship Management (VRM) according to its supply chain and business strategies. Moreover, in some innovations, the technology including usage of Internet, EDI, RFID and other IT is a big necessity.

Furthermore, companies should determine the extent of the alterations caused by the innovations. For instance, transformational innovations create wholly new types of products and processes doing the same activities. Incremental innovations which are the most common type of innovations consist of small changes made for the enlargement of the companies and they generally disallow big changes in the product, process or service. Radical innovations focus on the completely new product and process types rather than improving the current ones. Renewal innovations are implemented when

the products or services arrives their decline stage in its life cycle. Architectural innovations improve the ongoing processes and products to increase the productivity.

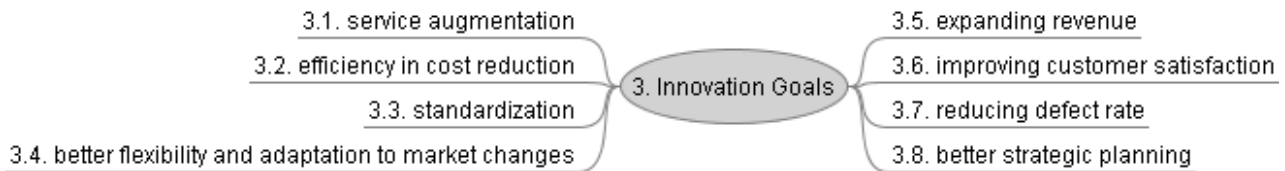
The decision phase at which the implementation of the innovations occurs can be determined by looking at the relationship of the supply chain and business strategies. These decision phases can be strategic, tactical or operational. In conclusion, the innovation can mainly focus on one or more of the supply chain partners consisting of customer, retailer, distributor, manufacturer and supplier. Although, these partners work together in the supply chain, the innovation emphasized on a specific one will affect the others in a different manner. Figure 2 gives the taxonomy of supply chain innovation attributes as a mind map.



**Figure 2.** Mind mapping for supply chain innovation attributes

## ***Determining Supply Chain Innovation Goals***

Different companies implement supply chain innovations for various purposes. These purposes can depend on the firm itself, which supply chain and innovation attributes are used among the ones defined above. While a company may focus on service augmentation by the help of supply chain innovations, another one can emphasize the efficiency in cost reduction, standardization, better flexibility or adaptation to the market changes, expanding its revenue, improving customer satisfaction, reducing defect rate and getting better strategic planning. Figure 3 gives the mind mapping of supply chain innovation goals as proposed in our taxonomy.



**Figure 3.** Mind mapping for supply chain innovation goals

## **Case Studies Related to Supply Chain Innovations**

We found a set of companies in the case studies including the implementations of the supply chain innovations. These companies took place in a contest for the Supply Chain Innovation Award organized by the Council of Supply Chain Management Professionals (CSCMP) (<http://cscmp.org/Resources/InnAward.asp>).

Nearly all the companies have increased their efficiency and potential market by reaching higher satisfaction levels, profit rates with on time deliveries and lesser costs by the innovations. The companies and organizations that participated in the competition to be selected as the best supply

chain innovator in 2007 are The AidMatrix Foundation (winner), Bakers Footwear, John Deere and Smart Ops, Kraft, Liquor Control Board of Ontario, Motorola and OceanSchedules.com. The candidates in 2006 are CEAG/FRIWO, Hewlett Packard, IBM, Kellogg's and CSCS, Mercy Roi (winner), P&G and The Dow Chemical Company. The firms that took part in the contest in 2005 are Blockbuster, Campbell Sales & Food Lion, Hewlett Packard Design, Hewlett Packard Procurement (finalist & winner), Kraft, Lexmark (finalist), Liquor Control Board of Ontario, National Oilwell Varco, United Technologies, U.S. Transportation Command (USTRANSCOM).

In this paper, we tried to examine these companies and organizations according to the supply chain and supply chain innovation characteristics mentioned in the previous section. We only examined a set of these companies which are open to public in the U.S. markets. It is important to bear in mind that since we used the current financial data of these companies, any relationship between the current company characteristics and the innovation fulfilled in two years ago may not be the same way as it would be at the time when company just initiated the innovation.

### ***A closer look to the companies***

Blockbuster, which is the biggest company selling videos, DVDs and video games, gained the award since it has a Consolidation Department that is used to combine different products coming from different distribution centres with the customer orders that will be routed to the same warehouse. It also uses *pool point distribution* in order to reduce the transportation cost. The main strategy of the firm is to use the containers as effective as possible by putting as many products as it can inside them. The company has also established extremely good relationships with the vendors, suppliers and customers.

Campbell Soup Company is a leading producer and merchandiser of convenience food products. In August 2004 the Campbell Soup Company started an Adjustable Rate Base Unsaleables policy with U.S. Retailers. In the development and implementation of the new policy, Campbell's devised a set of guiding rules. The primary principal of the new policy was to continue efforts with our trading partners to reduce the instances of unsaleables throughout the supply chain network.

HP took place in the competition in 2006 and won the award. It has established magnanimous relationships with its customers and suppliers by applying successful CRM and Supplier Relationship Management (SRM). It arranges meetings once in every three months to share the knowledge with the suppliers. Its strategy is always to lessen the number of central parts around the world. It uses E-sourcing and EDI for better knowledge sharing and more efficient business relations. Furthermore, Buy-Sell process is implemented in the company to control the product and material flows level better by using only one channel from the supplier to the manufacturer, so that they offer the customers constant product price for a long period of time. Also, HP is popular with its supply chain innovations made in the market by offering different prices after dealings, keeping the prices at a desired level based on the inflation rate and controlling the product deficiency in the market.

Kraft, which manufactures and markets packaged foods and beverages worldwide through its subsidiaries, took place in the contest in 2005. It is a well-known company to implement prosperous Supplier Relationship Management and to highlight the assessment of the supplier. SRM helps Kraft to maintain its development plan.

Lexmark is a designer, producer and supplier of printing and imaging solutions for offices and households. Its products include printers, multifunction devices, office supplies, services and solutions. Since the beginning of 2000s, Lexmark International, Inc. has put into practice various supply chain policies in order to raise its cash flow position. In 2005 contest, the company is awarded as finalist with these policies that lead to better cash – to – cash cycle time at Lexmark International, Inc.

National Oilwell Varco who is another participator of the competition in 2005 is a global player in the oil and gas drilling industry. It provides technological equipment and components, operates in oilfield services, and offers supply chain integration services. The company uses a central planning and buying system. By the help of the changes in its Enterprise Resources Planning (ERP) systems, the company's purchasing strategies became further efficient. The improvements in management activities have provided lower inventory level, transportation costs and higher market share with better Return on Investment (ROI) rate. The main goal of the supply chain innovations in the company is to reach a totally successful supply chain organization by delivering the appropriate product to the corresponding customer in the planned time.

United Technologies, provider of technology products and services to the building systems and aerospace industries, is another participator of the competition in 2005. It has lowered the costs and

reduced the risks, located its resources in an influential way by the help of Value Stream Mapping. Also, United Technologies controls the success of its suppliers. Since the company operates in aerospace industry and shares its know-how with its suppliers, the change of the suppliers can cause troubles to the company; therefore having good relationships with the suppliers is a critical fact for the company.

Another participant of the Supply Chain Innovation Award was IBM. IBM founded Internal Supply Chain (ISC) in 2003. Moreover, by the help of Supply Chain Business Process Innovation, vital changes have been applied to the processes and methods in the company. One of the most important innovations of IBM is *deal hubs*. These hubs support the relationships between the customers and vendors by giving a chance to the vendors to sell better quality products in a shorter response time. Another supply chain innovation of IBM is the model of *Workforce Management Initiative*. This approach mainly depends on concluding the customers' troubles rather than depending on increasing the sales. Since IBM is a large company serving in an international market, it also applies Integrated Supply Chain (ISC). Furthermore, in the recent years IBM has reduced the time spent for controlling the customer orders by 25 percent. A successful web based supply policy is implemented and customer satisfaction is considered as one of the most fundamental factors to increase the profitability by providing them an efficient delivery service.

Manufacturer of ready-to-eat cereal and convenience foods, Kellogg's CSCS uses "Closed Loop Returns Management System" as an innovative process in the supply chain. This system is used to increase the product sales by giving responsibility to all of the workers and not to an individual. The main goal of this practice is to increase the profit rate by developing the processes. Also, Kellogg's CSCS knows the importance of its customer suggestions and collaborates with the customers by applying CRM. Therefore, Kellogg's CSCS finds different methods of increasing the profit of its customers and suppliers by improving the products and linking its targets with the customers' goals.

P&G, leading consumer goods producer, can be given as a good supply chain innovator by the useful collaboration with its workers, suppliers, distributors and customers with CRM, SRM etc. Its main strategy is to innovate in all the aspects of business to reach a long-term success. Supply chain is understood as a powerful tool for the innovations in P&G. The company gives a high priority to the training of the workers for creating innovations and uses new performance measures such as *availability and shelf quality*. The main goal of the company is to reduce the time related the supply chain by 35% in next years, by delivering new products with the developed transportation techniques and increasing the responsiveness (Lafley, 2006).



Another participant company in the 2006 contest, Dow, is a large chemical company operating in various areas of business such as plastic, agriculture etc. It revised its supply chain strategies in order to reduce the number of transportations and the distances of shipments to prevent any critical products. It also uses RFID and GPS technologies to track the shipments. Furthermore, Dow uses vastly advanced container types for the hindrance of spoilage and any other incidents which can be occurred due to the chemical products. It also uses intermodal transportation including highway, marine and rail ways of transportation. Moreover, Dow has a Supply Chain Risk Management system in order to find more secure and effective distribution of the products in the context of ethic.

Bakers Footwear Group, Inc, retailer of distinctive footwear and accessories, has participated in the 2007 contest. Aware of the fact that by importing from source and delivering direct to the store, importers can eliminate days from the supply chain and reduce stock-outs, Bakers implemented DC Bypass. Bakers partnered with their Freight Forwarder, Transmodal Associates, and supply chain software provider IES Ltd. to create a solution to make DC bypass a reality - with a little help from our factories in China.

Motorola is a worldly renowned communications systems company providing mobile products and services across broadband, embedded systems and wireless networks. Before 2005, each of Motorola's business units was running its own separate supply chain. By transforming its previous structure into a new Integrated Supply Chain (ISC) organization to reach across all company businesses, functions and regions, efficiency and cost effectiveness are achieved.

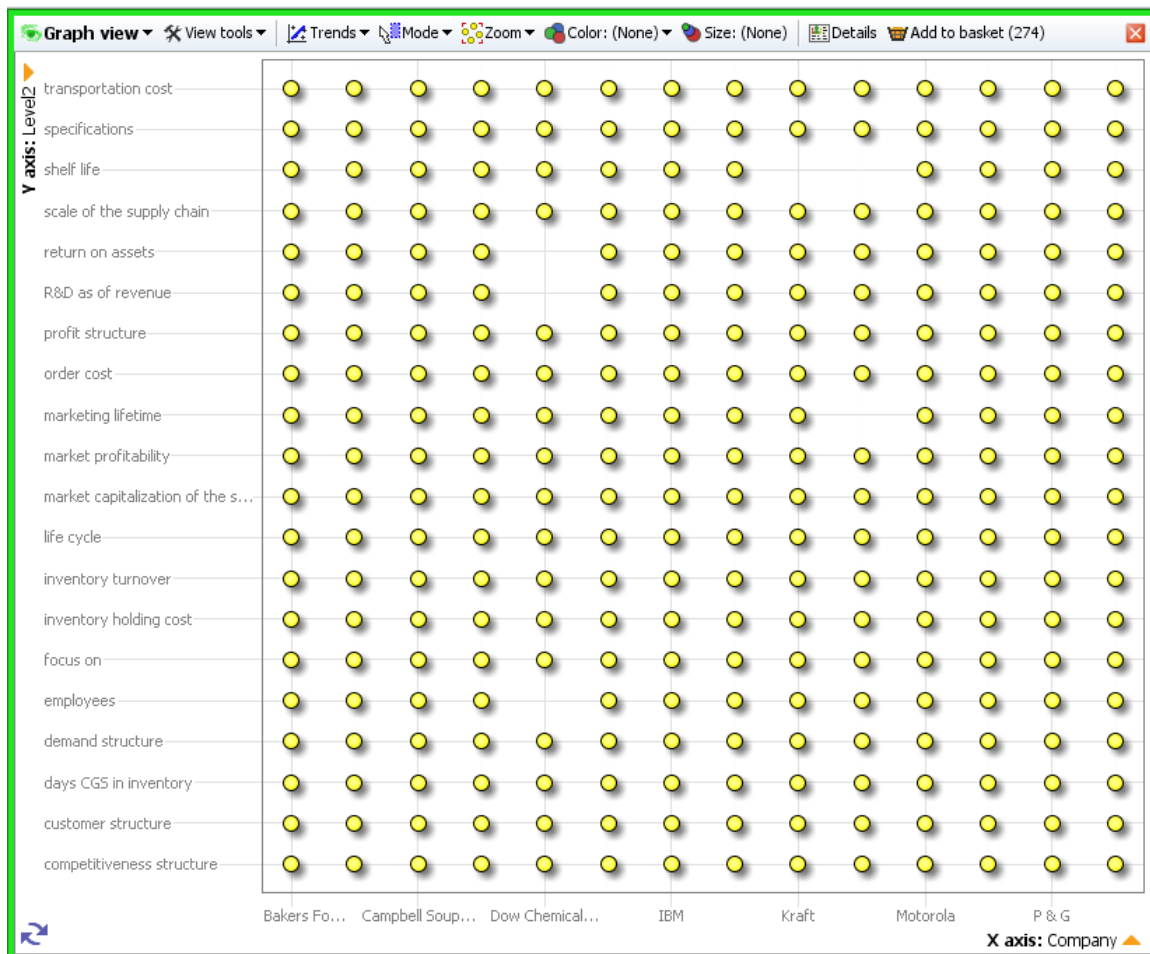
Deere & Company is a leading global manufacturer of equipment for agriculture, construction, forestry, commercial, and consumer products. In 2005, the company started with a new logistics initiative in order to be able to offer faster and more reliable replenishment to its North American dealers. It began planning a multistage distribution network and built a partnership with SmartOps, renowned inventory optimization software, to optimally design this network and to identify further cost saving opportunities.

## ***Data Quality Control***

In the methodology section, we have provided three main frameworks to investigate the companies in terms of supply chain characteristics, supply chain innovation characteristics and innovation objectives. After the data set of companies is secured, a detailed analysis is conducted to assign appropriate attributes to each company in these three frameworks. It is expected that each company in the data set has a value for all attributes in supply chain characteristics (Figure 1). For instance, in the analysis of CSCMP Supply Chain Innovations Award data, each company has a value for market competitiveness structure, market capitalization, market profitability, number of employees, R & D expenditure as a percentage of revenue, etc. On the other hand, each company may or may not have a value for all of the supply chain innovation attributes (Figure 2) considering the fact that each company may focus of different areas to improve the current performance. Similarly, the appropriate innovation goals of the companies are indicated in the supply chain innovation goals framework (Figure 3). A careful analysis is critical in this stage in order to get meaningful insights from the further parts of the data analysis. Thus, after the data matrices (Figure A1) are constructed to indicate the company attributes for these frameworks, data consistency check is needed before moving further. Various kinds of information visualization techniques can be used to check the consistency and completeness of the data. Figure 4 gives the scatter plot of supply chain attributes data where the company names are on the horizontal axis and supply chain attributes are on the vertical axis. In order to analyse and visualize the data, data visualization software Visokio Omniscope\* is used. Such data visualizations are very beneficial to understand the underlying patterns better and to draw critical insights easily. For instance, Figure 4 reveals that some supply chain attributes are missing in the current framework such as the R&D expenditure as of revenue for the Dow Chemical Company. In this case, it is appropriate to go back and complete the information missing for the supply chain framework.

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\* <http://www.visokio.com/omniscope>

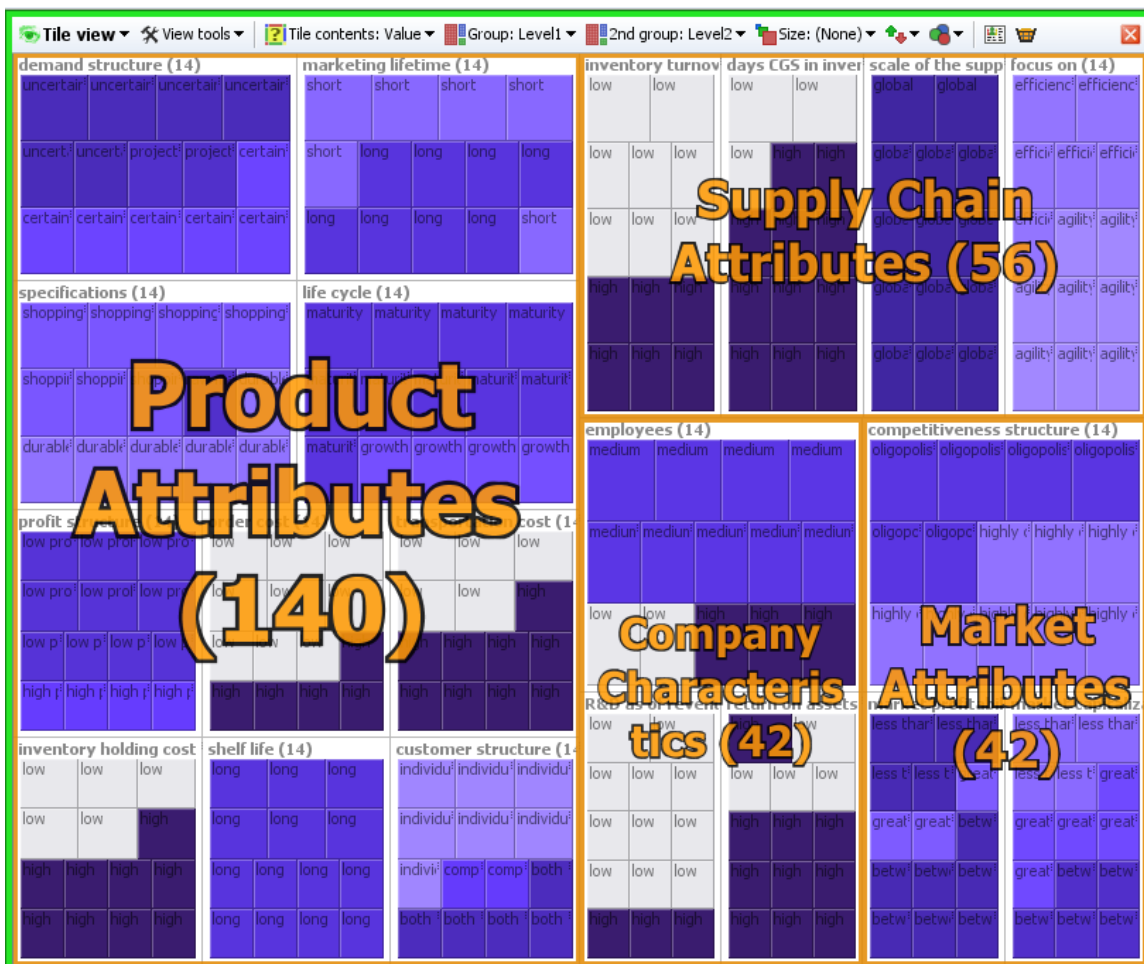


**Figure 4.** Identification of missing data

### ***Supply Chain Landscape***

The supply chain characteristics of a company are critical and should be carefully evaluated in order to understand and analyze its supply chain innovations. To be able to observe all of the supply chain characteristics those are suggested by our supply chain attributes framework effectively, matrix of companies is constructed to highlight the supply chain attributes of the companies (Figure A1). If a company carries an attribute, the corresponding cell of that firm is marked with an “X”. In Figure A1, the full data is given for only first three samples of companies. The illustration of supply chain

attributes in matrix form makes the analyzer aware of any patterns that are underlying in the data. In addition, all the information belonging to each company can be displayed in a single figure. It is also possible to make further visual analyses by means of this matrix form and information visualization software Visokio Omniscope. Figure 5 gives the tile graph for supply chain attributes of CSCMP data. The graph divides a particular area into appropriate surfaces with varying sizes in order to represent different patterns or attributes of the data by also using different coloring schemes. In Figure 5, the tile graph is formed by using two grouping criteria: The first level (i.e. Product attributes, supply chain attributes, market attributes and company characteristics) and the second level (i.e. attributes which belong to each of the groups in the first level, for instance, competitiveness structure, market capitalization and market profitability which are positioned under the market attributes of the first level). Different colors reflect different values for each of these attributes.



**Figure 5.** Tile graph for supply chain attributes of CSCMP data

## ***Innovations Landscape***

Similar to the analysis of supply chain attributes, supply chain innovations are also examined and classified according to the structure that we have discussed previously in the supply chain innovations framework (Figure 2). In evaluating the innovations carried out by each company, subjective judgments (i.e. whether the extent of change is radical or architectural) are also used in addition to the objectives criteria (i.e. tools used for innovation such as CRM, SRM, EDI, RFID, etc). What is critical is being consistent about the assumptions and decision criteria in evaluating different companies in terms of the supply chain innovations attributes. Figure A2 gives a sample supply chain innovations analysis for the CSCMP data. If an innovation carries an attribute, the corresponding cell of that firm is marked with an “X” similar to the analysis in the supply chain landscape. In Figure A2, the full data is given for only first three samples of companies. In order to understand and interpret the innovations fulfilled by different companies effectively, critical information visualization tools again make the job of analyzer more convenient. Tile graph for innovations attributes of CSCMP data is given in Figure 6. It is possible to discover hidden or underlying information by means of such figures, and quick insights from them can lead significant inferences about the relationships between types of companies and the innovations in their supply chain related activities. For instance, further research questions can be like the following: Which sectors do focus on innovation in strategic level? Which sectors do focus on tactical level? Where do most of the companies in a specific sector do their supply chain innovations? At warehousing, at purchasing, at packaging or at distribution and transportation? At which stage these innovations are achieved mostly? Innovations landscape provides important insights for such key analyses. For example, the tile graph given in Figure 6 indicates that almost all of the companies in the current data set committed strategic and tactical level supply chain innovations. It also shows that nearly half of these innovations are architectural, while most of the remaining is radical, a reasonable part of them is incremental and only a slight part is transformational. Similar analyses can also be carried out for other supply chain innovations attributes; most of these analyses are not difficult to interpret due to the clarity and self-expressiveness of the tile graph. The supply chain innovation goals framework given in Figure 3 is also used to evaluate the companies according to their objectives in the corresponding innovations. Figure A3 gives the matrix of companies by supply chain innovation goals; if a company committed a supply chain innovation for a particular objective, the corresponding cell of the matrix at the intersection of that innovation and the company is marked with an “X” similar to the previous matrices formed in

supply chain attributes and supply chain innovations framework. In Figure A3, the full data is given for only first three samples of companies.

### Conclusion and Future Research

In this study, we presented a structured approach to analyze and interpret supply chain innovations. The methodology and main framework are given and we strongly believe that the companies can position themselves in the competition better by designating their supply chain structure, supply chain innovation attributes and goals in the taxonomy we presented.

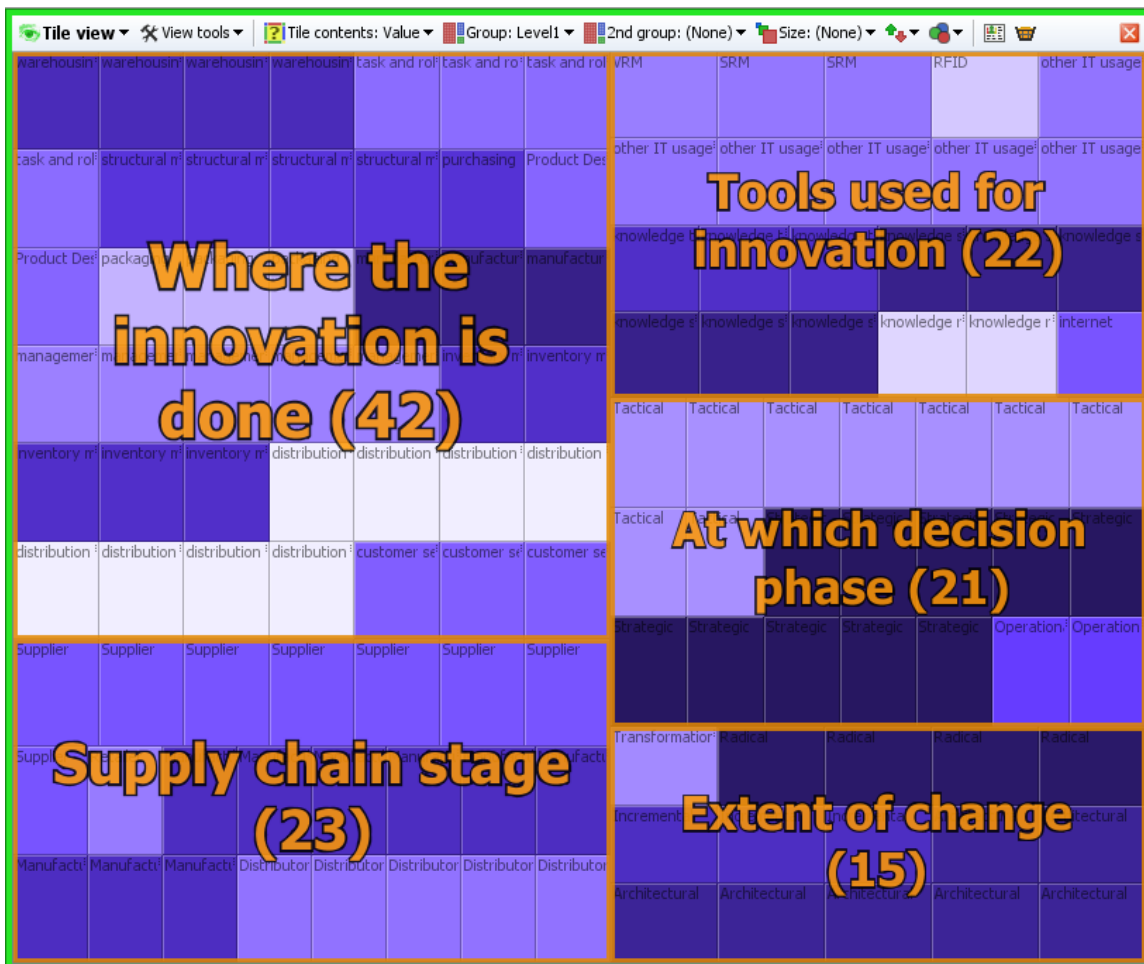


Figure 6. Tile graph for innovations attributes of CSCMP data

It is possible to summarize the contributions and future research of this study in terms of four main topics:

1. We suggested a three-component framework in order to map supply chain innovations in an easy but effective manner. These components are supply chain attributes, supply chain innovation attributes and supply chain innovation goals. The first two can be regarded as a detailed taxonomy of supply chain and innovation characteristics.
2. We presented the implementation of this structured framework by using real world data and answered the questions regarding to the data collection, data consistency check and decision making in subjective matters by demonstration of making assumptions and subjective judgements.
3. An analysis framework is proposed by using data visualization techniques. Sample visualizations are provided to make the reader aware of the extent of possible insights about supply chain and innovation attributes of companies
4. In this study, what we focused on is the framework to understand supply chains and related innovations. Moreover, we illustrated the application of this structured framework by using sample company and supply chain innovation data publicly available on the Internet. In order to get further insights about various industries and supply chain innovation characteristics belonging to them, richer and more detailed company data (i.e. large number of companies from diverse industries emphasizing on supply chain innovations) can be used to maximize the benefits achieved by the use of our framework.

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**Table A2. Matrix of Firms by Innovation Attributes**

Firm	2.1. Where the innovation is done		2.2. Tools used for innovation				2.3. Extent of Change					2.4. At which decision phase the innovation is done		2.5. Supply chain stage				
	Process	Organization	Knowledge	Relationship Networks	Technology	Transformational	Radical	Achittectural	Incremental	Renewal	Strategic	Tactical	Operational	Customer	Retailer	Distributor	Manufacturer	Supplier
1 Blockbuster	X									X								
2 Campbell Soup Co.	X										X							
3 Hewlett Packard	X		X															
4 Kraft																		
5 Lexmark																		
6 National Oilwell Varco																		
7 United Technologies																		
8 IBM																		
9 Kellogg CSCS																		
10 P & G																		
11 Dow Chemical Company																		
12 Bakers Footwear Group																		
13 Motorola																		
14 Deere & Co.																		

**Table A3.** Matrix of Firms by Supply Chain Innovation Goals

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
		Blockbuster	Campbell Soup Co.	Hewlett Packard	Kraft	Lexmark	National Oilwell Varco	United Technologies	IBM	Kellogs CSCS	P & G	Dow Chemical Company	Bakers Footwear Group	Motorola	Deere & Co.	
3.1.	Service Augmentation															
3.2.	Efficiency in cost reduction	X		X												
3.3.	Standardization															
3.4.	Better flexibility and adaptation to market changes	X		X												
3.5.	Expanding revenue															
3.6.	Improving customer satisfaction	X	X	X												
3.7.	Reducing defect rate	X	X													
3.8.	Better strategic planning	X		X												