Generic Integration of Lean, Agile, Resilient, and Green Practices in Automotive Supply Chain

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Abstract

The purpose of this research is to development of a generic integrate approach for Lean, Agile, Resilient, and Green practices in automotive supply chain. A backward integration approach is followed starting from analyzing values of end customers through employing Bayesian network thereafter-qualitative correlations between supply chain practices and customer values are presented as the generic integration. Data about six customer values in automotive industry is presented and analyzed, and afterwards it is connected to supply chain practices resulting in the generic integration. Supply chain decision makers can benefit from this research in employing appropriate practices. In addition, this research contributes to marketing scholars in automotive industry by providing analysis of empirical data.

Keywords: *automotive industry, Bayesian network, Supply chain integration; supply chain practices*

JEL classification: O21, C30, C61, M10

Introduction

Supply chain refers to the complex network of relationships that organizations maintain with trading partners in order to procure, manufacture, and deliver products or services. It encompasses the facilities where raw materials, intermediate products, and finished goods are acquired, transformed, stored, and sold to end customer in downstream end. These facilities are connected by transportation links along which materials and products flow. Supply chain may consist of many companies, individuals and institutions (Pramod & Garg, 2006). Supply chain management is the coordination of material, information, and financial flows between and among all the participants. There are large number of paradigms introduced by scholars and practitioners to reach the aim of supply chain management many of which are developed in automotive industry. Besides, in order to reach these objectives it is required to integrate diverse entities, which are operating along the chain. Supply chain integration aims for this purpose to facilitate cooperation of different players of the chain by identifying the

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relationship between employed practices in the system and their contribution on customer values.

In the current research generic supply chain integration is developed based on customer expectations which are identified under six customer values namely quality, time, cost, customization, know-how, and respect for the environment. Following the analysis of customer values, supply chain practices which are contributing to customer values are identified in terms of manufacturing / assembly and logistics practices.

Bayesian network (BN) is a probabilistic model which is capable of computing the posterior probability distribution of any unobserved stochastic variables, given the observation of complementary subset variables. Due to strength of BN, its application has increased in different supply chain related fields. In the current research, BN is employed as a tool to data mine customer value data.

The current research is focused on automotive supply chain and the dataset is limited to corresponding customer values to this specific industry. Therefore, finding of the research is applicable for automotive industry. However, we assume that the same methodology can be used to develop integration model of other industries, as shown in Figure 1.

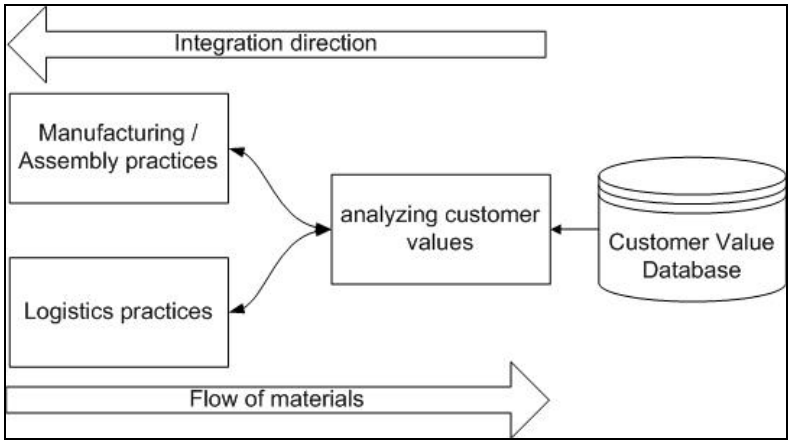

Figure 1. Generic structure of integration approach

1. Supply Chain Integration

Supply chain integration is the combination of efforts to integrate supplier and customer information and inputs into internal planning through cross- business relationships and internal cross-functional teams (Narasimhan, et al., 2010; Rosenzweig, et al., 2003). In macro scale, integration can be whether internal or external. Internal integration focuses on the integration of processes and transactions inside firm to develop its competitiveness. External integration encompasses both customer and supplier integration. Customer integration is the

process of acquiring and assimilating customer requirements information and related knowledge. Supplier integration is the process of acquiring and sharing operational, technical, and financial information and related knowledge with the supplier and vice versa (Adobor & Mcmullen, 2007; Swink, et al., 2007). Firms may have different integration maturity levels that can be increased by incorporating practices and employing e-business models (Kim, 2006). In the literature supply chain performance have usually categorized into four groups: quality (Shepherd & Günter, 2006), time (Whicker, et al., 2009), cost (Gunasekaran, 2004), flexibility (Angerhofer & Angelides, 2006), and green (Hazen, et al., 2011). They have also been grouped by quality and quantity, cost and non-cost, strategic/operational/tactical focus, and supply chain processes (Cai, et al., 2009). In addition, Ketchen, et al. (2008) identify competitive priorities of value supply chains as speed, quality, cost, flexibility.

The other perspective toward integration is to take paradigm perspective and combine different paradigms to get the most effective ones. In this respect Lean six sigma (Lee & Wei, 2009), TPM and TQM (Kedar, et al., 2008), Leagile (Mason-Jones, et al., 2000) and other confusion of paradigms have been introduced by scholars. In the recent years combination of four paradigms namely Lean, agile, resilient, and green (so called LARG) was introduced. Carvalho & Cruz-Machado (2009) have individually characterized Lean, Agile, Resilience, and Green according to their purpose, manufacturing focus, alliance with suppliers and customers, organizational structure, approach to choosing suppliers, inventory strategy, lead time focus, and product design strategy. Besides, another research conducted by Cruz-Machado & Duarte (2010) points out trade-offs among these four supply chain management approaches. LARG supply chain is considered as one integrated approach which has its own characteristics although it is clear that they are rooted in the major four initial approaches. In addition, LARG supply chain practices are introduced by Azevedo, et al. (2011) which paved the way for development the integration model. The current research positions itself as a follow up to their work attempting to develop a generic integration approach which connects LARG supply chain practices to customer values.

Carter, et al. (2009) conduct several case studies and based on their findings they conclude that well integrated supply chains are not ubiquitous at this time (notice that this research was published in 2009). There are certainly many success stories and many pockets of excellent supply chain integration. There are also many cases of failures and breakdowns in integration. Through this research, they have identified 14 key challenges organizations must meet to achieve true supply chain integration. The integration approach proposed by current research is directly and indirectly contributing to three of those challenges namely develop customer-centric metrics, create an effective Sales and Operations process, and develop the capabilities and analytic tools required to make effective decisions in an increasingly complex and risky environment.

2. Customer Values

The concept of customer value and its increasingly unanimous recognition as an imperative focus in research and practice has attracted attention of marketing researchers and practitioners during last thirty years (Blocker et al., 2010). Although body of literature has extensive theoretical materials emphasizing the importance of customer value, due to absence of measures few empirical studies are available in this area (Lapierre, 2000). Besides, remarkably few firms have the knowledge and capability to actually assess the connection between their industrial practices and the value their customers perceive. Nowadays, since firms define themselves in the context of their supply chain, it is critical for them to link their supply chain practices and align them with requirements of end customer. Graf and Maas (2008) argues that there is no concrete definition of customer value but generally there are two theoretical differentiable approaches regarding company perspective and customer perspective. Company perspective stream is closely related to relationship marketing, which aims at developing and maintaining profitable business relationships with selected customers (Krafft, et al., 2005). While customer perspective is focus on value generated by a company's product or service as perceived by the customer or the fulfillment of customer goals and desires by company products and/or services (Bala, 2012). Blocker (2011) emphasizes the fact that customer value research in business-to-business markets burgeons, many scholars circumscribe its progress to domestic and western markets studies and call attention to the lack of consensus on how to model customer value. Blocker (2011) developed a conceptual framework for measuring customer value and value drivers in business service relationships which is a follow up to his prior work on assessing the impact of proactive customer orientation on value creation (Blocker, et al., 2010). Ulaga (2011) commentary cites that Blocker's (2011) study lays foundation for additional research questions from both theoretical and methodological perspective. The current research positions itself as a follow up work in this context.

Accepting the fact that customer value is hard to grasp, scholars have tried to understand it by categorizing it into clear terms. Hayes & Wheelwright (1984) adopt the company perspective and identify customer values as price (cost), quality, dependability and flexibility. Taking the same perspective Roth & Van Der Velde (1991) identify four factors in their research, namely quality, delivery, flexibility and cost. The current research categorizes customer value into six clear terms from literature namely: Time (Droge, et al, 2004; Whicker, et al., 2009), Quality (Gallarza, et al., 2011), Cost (Whicker, et al., 2009), Respect for the environment (Dibrell, et al, 2011; Roberts, 1996), Customization (Bask, et al., 2011; Du, et al., 2003), and Know-how (Gruen, et al., 2006).

3. Bayesian Network

Bayesian network (BN), also known as belief networks or Bayes nets in short form, belong to the family of probabilistic graphical models which are employed to represent knowledge about uncertain domain. BN combine principles

from graph theory, probability theory, computer science, and statistics (Gopnik & Tenenbaum, 2007; Li & Gao, 2010). BN has appeared as a powerful practical tool to represent knowledge, primarily through the seminal research by Professor Judea Pearl at UCLA. Since that time on, it has presented its computational power for deep understanding of very complex, high dimensional problems. Efficiency in computation and inherently visual structure of this tool has made it even more attractive for researchers and practitioners to explore and explain complex problems (Pearl & Russell, 1998). It worth noticing that BN can be considers as a disruptive technology due to the fact that it challenges a number of common practices in business and science (Bayes theorem has had the same challenge since the time it was introduced).

BN has following advantages: (a) it is a powerful method to treat missing value problem; (b) due to the knowledge of casual relationship between variable it is good in prediction; (c) it allows the easy use of prior knowledge; d) the probability propagation may be used "backwards" also, when the aim is to find the most probable scenario explaining the evidence set (Neapolitan, 2003).

Several authors such as Boudali & Dugan (2005), Langseth (2007), Mahadevan, et al. (2001), Muller, et al. (2008) and Weber & Jouffe (2006) have recommended this approach as a comprehensive method to derive relationships and influences among variables. BN has also been successfully used in a variety of topics related to supply chain such as suppliers evaluation (Yuan, et al., 2009), Decision support under uncertainty in collaborative networks (Shevtshenko & Wang, 2009), Forecasting customer demand (Kiekintveld, et al., 2009), Scenario analysis (Cinar & Kayakutlu, 2010), and Reverse supply chain (Xing, et al., 2010).

4. Integration Approach

Supply chain integration includes two streams. Firstly, the pattern in customer values should be identified through data mining. Authors of the current research recommend employing BN to find how are customer values influencing each other. In another word, it is possible to find out in case one customer value is important for a customer how does that person evaluate other values. In the second stream, customer values are connected to LARG supply practices in order to ensure that employed practices in supply chain are actually contributing to customer values.

4.1 Customer Value Data

Six customer values namely time, quality, cost, customization, know-how, respect for the environment are investigated in this research. Data about these values is collected through a questionnaire which led to collection of 590 records for each value in automotive industry. According to the results of this questionnaire quality is the most important customer value by having the highest check marks as the "most important" that is 21.36% and the least check marks as the "least important" that is 4.07% (a few respondents finds quality the least important value). Cost is closely following quality by being the most important customer value by 20.00% and only in 4.58% it is considered as the "least important". Till

here our results in automotive industry confirms the findings of the research by Hu et al.(2009) recognizing quality and cost as winning factors. After quality and cost, the order of rest of the customer values is respect for the environment, know-how, customization, and time as being the "most important" by respectively 16.78%, 6.95%, 6.78%, and 2.54%. Noticeably, respect for the environment took higher importance comparing to know-how, customization, and time which confirms the result of the survey conducted by González, et al. (2008) that take company perspective and verify there is a positive relationship between the possession of certified EMS, specifically ISO 14001 and eco-management and audit scheme, and the environmental demands. And eventually time is the loser among the identified six customer values by being the "most important" customer value by only 2.54% and 29.49% of respondents chose it as the "least important" (Figure 2).

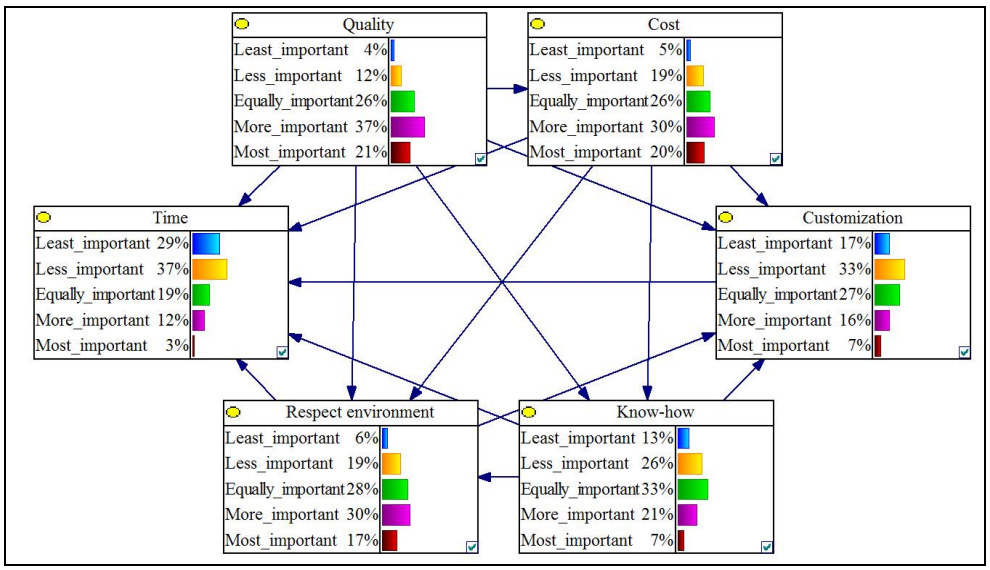

Figure 2. BN of customer value data in automotive industry

Customer values are presented as nodes of BN in Figure 2 where each node has five states representing data of the questionnaire dataset. Arcs between nodes illustrate mutual influences between customer values data which are identified through learning BN network from dataset. More than illustrating the dataset this network has the capability to simulate different scenarios. Firms can use this potential to introduce specific preferences of their customers to the network and simulate customer values for particular cases. For instance, in case for a specific customer quality and cost are the most important customer values, based on our dataset, customization and respect environment will have 31% importance that is 26% higher than general state for customization and 17% more than general state for respect environment. Different states of customer values for this particular case are presented in Figure 3. Employing this tool opens up the opportunity to

introduce known preferences of customers and predict others. Having true perception of customer values is the prerequisite for the next stage that is providing value product for them. Supply chain practices should be objectively integrated to these values in order to get higher customer satisfaction.

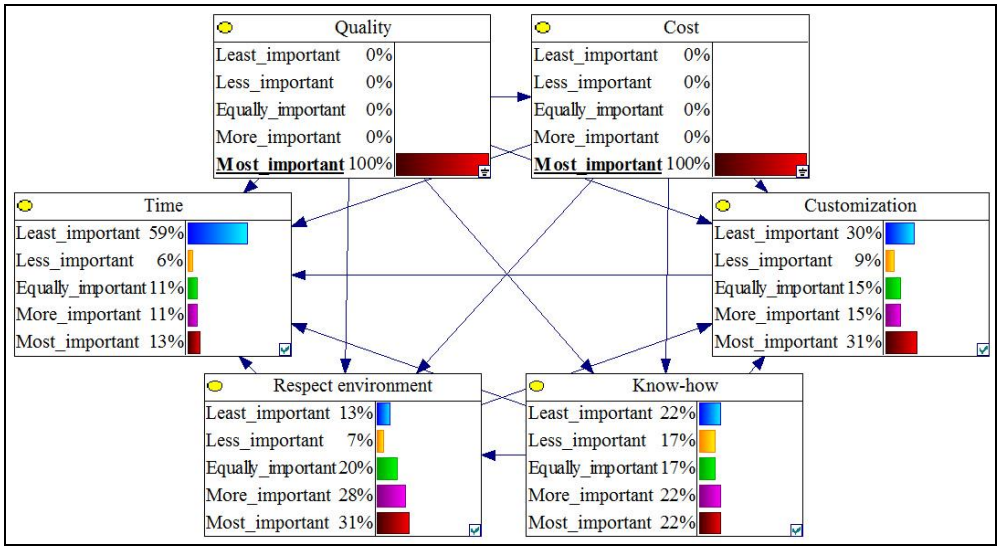

Figure 3. BN of customer value data in automotive industry: in case there is evidence that quality and cost are the "most important" values

4.2 Integration of Supply Chain Practices and Customer Values

This section looks specifically into LARG supply chain practices introduced by Azevedo. et al. (2011) and connect them to identified customer values. Taking a macro perspective, supply chain practices are divided into two major categories as manufacturing / assembly and logistics practices. Each supply chain practice contributes to some (or one) of customer values (Table 1). The main focus of practices is on cost. Particularly six of manufacturing / assembly practices and six of logistics practices are contributing to cost. Whereas only two of manufacturing / assembly and one of logistics practices are contributing to quality which is the most important customer value. On the other hand five of manufacturing / assembly and six of logistics practices are contributing to time. It can be explained by considering the point that cost and time are tightly connected as saving time results in reduction of costs. On the other end, there is only one practice (manufacturing transparency to customers) in manufacturing / assembly and one (information sharing with customers) in logistics that contributes to customer know-how. Providing information and knowledge about manufacturing and logistics of products to customers is so critical that Mujuni Katunzi (2011) defines supply chain integration as a process of redefining and connecting entities

through sharing information. According to the research by Gruen et al. (2006) as customers receives more knowledge about products, their royalty increases. Therefore, manufacturing transparency and logistics information sharing are important practices to provide info for customers and keep them loyal.

Table 1. Relevant customer values and their connections with LARG supply chain practices

	Customer values **LARG supply chain practices**	**Time**	**Quality**	**Cost**	**Customi-zation**	**Know-how**	**Respect environment**
Manufacturing / Assembly Practices	Cycle time reduction	↓		↓			
	Setup time reduction	↓		↓			
	Batch sizing	↓		↓	↑		
	Lead time reduction	↓		↓			
	Manufacturing transparency to customers					↑	↑
	Modularization	↓		↓	↑		
	Flexibility to demand change				↑		
	Reduction of raw materials variety			↓			↑
	Demand-based management		↑				
	Cooperate with product/ production designers to decrease environmental impacts		↑				↑
	Number of practices	5	2	6	3	1	3
Logistics Practices	Visibility of upstream and downstream inventories	↓		↓			↑
	Information sharing with customers					↑	
	Modularization	↓		↓	↑		
	Just in time	↓		↓			
	Flexibility	↓		↓	↑		
	Supplier relationships	↓	↑	↓	↑		
	Lead time reduction	↓		↓			
	Number of practices	6	1	6	3	1	1
Legend: ↑ increase the performance of customer value; ↓ decrease the performance of customer value							

Conclusion

This research classifies LARG supply chain practices into manufacturing / assembly and logistics practices then connects them to six customer values. Customer value dataset contains 590 records from end consumers in automotive

industry. The dataset is analyzed with Bayesian network and relationships among customer values are identified. Quality and cost are identified as the most important customer values and after them come respect for the environment, know-how, customization, and time. There is rich literature emphasizing quality and cost, this research expands it into prioritizing other customer values. In addition according to our finding time is least important customer value. In another words, time will be important to customers only if other values are satisfied. Although there is a relatively high importance of respect for the environment and know-how from customer perspectives, not many supply chain practices are dedicated to them. Therefore, this research raises attentions for further studies specifically on these customer values. On the other end, time is identified as the least important value in trade-off approach, which means customers prefer to sacrifice time in order to get more in other values.

Supply chain decision makers may benefit from both phases of the current research. Analysis of customer values with trade-off approach clarifies customer preferences in automotive industry. Furthermore, in case the decision maker is in a position to sacrifice one factor to increase another, this approach shows which one is more in favor of the end customer. Besides, BN makes it possible to simulate preferences of one specific customer given one (or more) known factors. The second phase of the research provides decision makers with a number of LARG practices connected to customer values. Knowing the importance of each customer value, trade-off among values, and LARG practices provides rich foundation for supply chain decision makers to take the most appropriate decision.

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