Multiple Dimensions to Measure Supply Chain Performance in Manufacturing Industries Based on AHP

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Introduction

One of the most significant paradigms shifts of ultramodern business operation is that individual businesses no longer contend as entirely independent realities, but to a certainextent as force chains. Enterprises worldwide have settled the conception of force chain operation as important and occasionally critical to their business. Supply chain (SC) is a network conforming of guests, retailers, wholesalers, manufacturers, suppliers, and service providers (Hugos, 2003). The primary end of each force chain is to maximize the overall value generated.

In moment's largely competitive terrain, force chain performance is veritably pivotal for the abidance of enterprises because guests judge the performance of enterprises grounded on their force chain performance. The nature of the supply chain is characterized by parameters similar as product demand, product variety, product life- cycle, product quality, service quality and other factors (Agarwal etal. 2006). Actually, modern force chains aren't simple chains or a series of processes, but are complex networks where dislocations can do at any time (Christopher, 2004). According to Christopher and Peck (2004), understanding and managing the processes that comprise force chains is critical for the reduction of implicit pitfalls. Therefore, the force chain terrain is moment more dynamic and changeable than in the history. Koh etal. (2007) describe some functional performance constructs which include inflexibility, reduced lead time in product, soothsaying, resource planning and cost saving and reduced force position. Khang etal. (2010) proposed six confines of SC practices which include Client exposure, knowledge sharing, IT relinquishment, cooperation, leadership and training to examine their impact of organizational performances. Agus and Hajinoor (2012) describe several variables measuring spare product practices similar as setup time reduction, nonstop enhancement programs, pull product system, shortersuperemient time, and small lot size for enhancing product quality and business performance.

A review of literature on SCM practices directed that a great extent has been written about SCM practices and performance in different sectors but little attention has been paid to prioritizing these practices. On the other hand, there is critical need to identify the measure for shaping accomplishment priority of SCM practices for their successful performance in manufacturing Industriousness.

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In order to link this gap, the present study uses a logical scale process (AHP) approach to determine the relative significance of different confines in the manufacturing industriousness. For this purpose, the disquisition aimed at achieving the following objects

(i) To examine and orders the confines of manufacturing industriousness.

(ii) To prioritize the relative significance of these confines for performance so that manufacturing industriousness can estimate their current practices to meliorate their SCM performance.

This paper is structured as follows. Section 2 presents the literature review. Section 3 consists of a prolusion to AHP. Section 4 consists of disquisition methodology predicated on AHP proposition. In section 5 results and analysis are presented followed by the limitations. Ultimately, conclusion and compass of future disquisition are presented in section 7.

Literature Review

The focus of this study was to identify the various practices in manufacturing industries that results in improved business performance and customer satisfaction. In this study, 10 dimensions have been identified from the literature and discussion with experts and academician in the SCM area keeping manufacturing sector in focus that can impact the SCM performance are explained below.

Identification of Various Dimensions in Manufacturing Industries

Demand Forecasting (DF)

In supply chains, predicting is an important determinant of functional performance. Demand forecasting is a pivotal aspect of the planning process in supply- chain companies. The most common approach to forecasting demand in the companies involves the use of a computerized forecasting system to produce original forecasts and the ensuing hypercriticaladaptation of these vaticinations by the company's demand planners, evidently to take into account remarkable Surroundings anticipated over the planning prospect. Making these adaptations can involve considerable management effort and time, but do they enrich delicacy, and are some types of acclimations more effective than others?

Lead Time (LT)

Lead time can be defined as the time between ordering the product and admitting it. LT can be affected by a variety of factors including controllable ones similar as ineffectivetransportation, incorrect information systems, and uncontrollable ones similar as weatherchange, unforeseen events, and so on. All of the prior- mentioned factors are suitable to generateuncertainty in the lead time. Lead time (LT) is a central parameter that differs and affects allsupply chain (SC) partners. Lead time also depends on stock, ordering and replenishmentprograms. Thus, lead time reduction can be viewed as a coordination enabler in supplychain. Wang etal. (2008) researched the impact of lead time on bullwhip effect. They hadshown that bullwhip effect increases with the increase in lead time. Heydari etal. (2009) explained the lead time variability in a periodical supply chain and had shown that the order variability increases with the increase in commanding time variability.

Inventory Policy (IP)

Inventory policies specify decision rules with respect to the point in time when a loss of the stock should be initiated as well as to the loss volume that should be ordered from the supplying lump in the force network. Stock and order procedures areinter-related, since order volume and time of ordering depends on the force status.

Number of Echelons (NE)

A typical supply chain contains several situations, and each stratum can include multitudinous installations, performing in complex structures. The complexity of the force chains arises, in particular, from the number of situations in the number of installations per stratum (Beamon, 1999). Clearly, ultramodern force chains encompass possessed or contract manufacturing andtransportation Installations, suppliers, distributors, and client service centers scattered over the globe (Bottani and Montanari, 2011). In a force chain, each link represents the inflow of accoutrements and information that make possible the functions of procurement, processing (or manufacturing), storehouse, and distribution. Any given force chain, each functional position comprises a stratum, and there may be multitudinous facilities within each stratum.

Company Processes (CP)

According to Moyaux et al., (2007), company processes indicate the variability of machinereliability and output and variability in process capability and subsequent product quality (Taylor, 1999). These problems may cause uncertainties among companies which in turn maylead to the greater order variability (Taylor, 1999).

Mutual Understanding Factors (MUF)

Trust is a favorable attitude that exists when on force chain member has confidence in other force chain member (Anderson and Narus, 1990). Trust is needed for inflow of information in the supply chain. Threat and price sharing influence individual supply chain member's geste and his interaction with other force chain members. Conflicts of interest are likely to occur when existing risk and. reward sharing maximize individual benefits in spite of the benefit of all supply chain members (Cachon and Lariviere, 2005). Trust and commitment are essential for enhancing performance of force chain in developing countries (Bianchi and Saleh, 2010).

Flow of Information (FI)

Information sharing between supply chain members is essential for a responsive supply chain (Stanley etal., 2009). Information sharing may be participating of the inventory data, demanddata and product quality data. The traditional communication between the manufacturer and the retailer is framed through constant ordering in large batches. This ordering geste distorts real demand information because demand variance becomes wide-reaching. (Ozer, 2003). According to Arshinder etal., (2007). sharing of information between force chain members helps to substitute information with inventory and lead time, reduces the force chain costs, reduces the demand variability enhances responsiveness and improves the service position.

Responsiveness Factors (RF)

The responsiveness of supply chain describes how quickly it responds to customer input. Liet al., (2008) explored that for responsive supply chain, agility in supply chain is an importantfactor. Mehrjerdi (2009) stated that responsive supply chain ensures delivery in time, cost reduction and accurate forecasting of data.

Quality Improvement (QI)

Quality is a measure that fulfils client demand in terms of the overall features, characteristics and oneness of a product or services (Chan. 2003). Supply chain quality management (SCQM) is defined by Foster (2008) “a system-based approach to performance enhancement that leverages chances created by upstream and downstream connection with suppliers and guests”. Measuring the quality performance of the product is the way to not only improve the various SC processes but also at the same time to ensure the consumer satisfaction position.

Quality management practices reduce process friction, which has direct impact on SCP measures, including supply and time measures, similar as cycle time and delivery dependability. Tan et al. (2002) studied a complete set of SC dimensions and SCP criteria and established that while some dimensions had a positive result on performance and some others had an undesirable result. Kaynak and Hartley (2008) progressed SEM model showing the co-operations between QM practices and upstream and downstream realities in the SC.

Information Distortion (ID)

Information distortion is the main cause of the bullwhip effect. The information distortion affects the deals and operations performance of the company and has also influence on the inventory situations. Information deformation gives actors in the chain the wrong revocations and is the contrary of sound collaboration and communication within the chain.

Introduction to AHP

Analytic hierarchy process (AHP), is a multi-criteria decision- making tool developed by Saaty (1980), uses a methodical procedure for representing the rudiments of any problem, hierarchically. It's designed to putrefy a complex, multi-criteria problem into multiple situations of hierarchy with the top position as the goal or objective, while the intermediate situations are the criteria and sub- criteria, and the smallest position offers alternatives, forming a hierarchy structure (Saaty 1980). It develops precedence’s among all the criteria and sub-criteria, within each position of the hierarchy. The system is grounded on both predetermined measures and expert judgments throughout the systems which are calculated through comparisons. The AHP system is extensively applied in different areas with different operations as apparent from literature listed in Table 1. Authors in the current study make use of AHP to estimate and finally prioritize the various dimensions critical to SC performance.

Table 1 Application of AHP in Literature

Authors	AHP application
Tam and Tummala (2001)	**Use of AHP in vendor selection of telecommunication system**
Chin et al. (2002)	**Priority and ranking of TQM practices in manufacturing industries**
Saaty et al. (2003)	**Allocation of intangible resources**
Law et al. (2006)	**Prioritizing the safety management elements for manufacturing enterprises**
Bhagwat and Sharma (2007)	**Application of AHP model for performance measurement in SCM**
Lam et al. (2008)	**Organizational learning model for vocational education**
Lin and Juang (2008)	**Application of AHP in biotechnology industry**
Dey and Cheffi (2013)	**Use of AHP for measuring green supply chain performance in manufacturing organization**

Research Methodology

In order to examine the relative priorities of various dimensions, this research paper uses the AHP approach. Figure 1 illustrates a flowchart comprising various footsteps to conduct the AHP method.

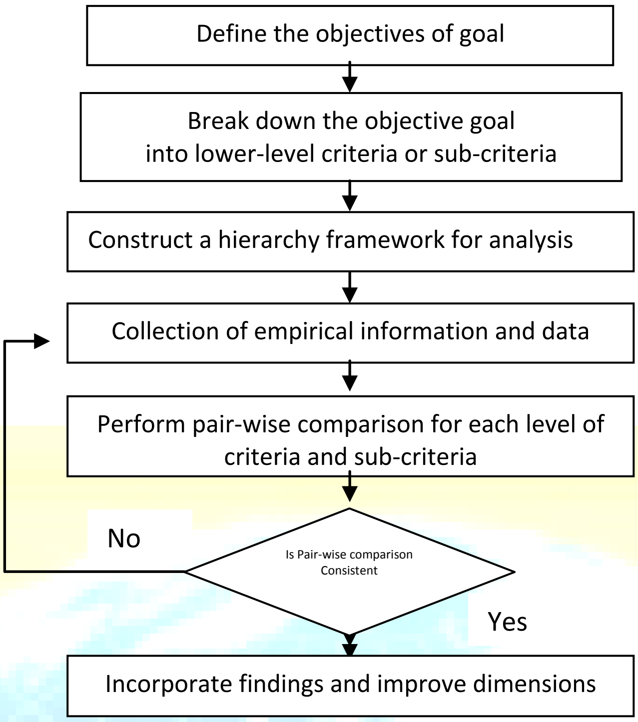

Figure 1 Flowchart to Conduct AHP Study

Step 1: Define the Objective or Goal:

The objective of the study is to identify the multiple dimensions and to priorities them.

Step 2: Breakdown the Objective or Goal into Lower-Level Criteria:

In this phase, the objective of various dimensions was decomposed into ten dimensions identified from the literature so as to form a hierarchical conception of the problem. The factor categories are Demand forecasting (DF), Lead time (LT), Inventory policy (IP),Number of echelons (NE), Company processes (CP), Mutual understanding factors (MUF),Flow of information (Fl), Responsiveness factors (RF), Quality improvement (QI),Information distortion (ID).

Step 3: Establishing the Hierarchical Structure:

Construct the hierarchical structure from the overall objectives to the various stages. Saaty (2000) suggested the guidelines for selection of different levels of criteria and construction of the hierarchy structure. On the basis of these guidelines, an AHP framework was developed for facilitating the study, as shown in Figure 2.

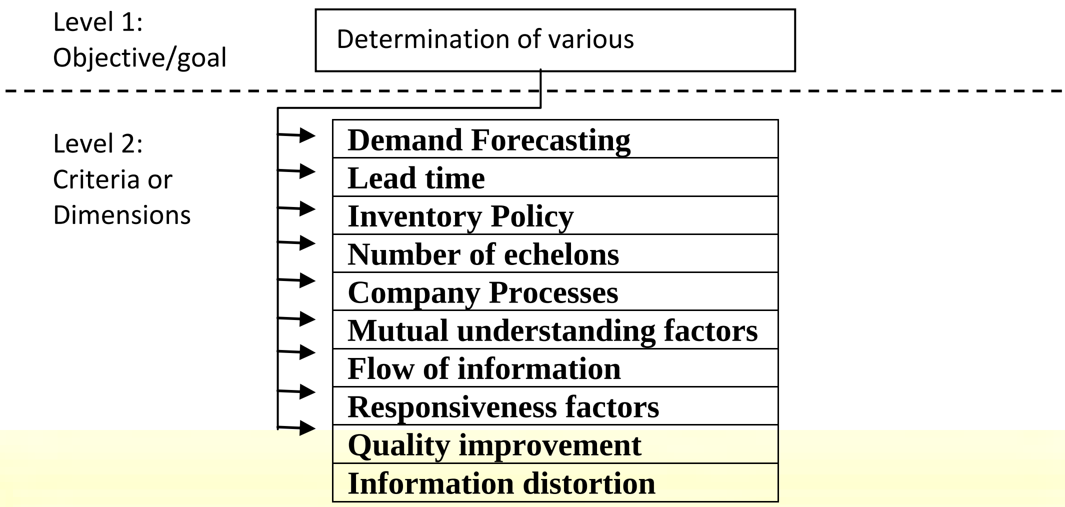

Figure 2 A hierarchy Model of Different Dimensions for the AHP Study

Step 4: Collection of Empirical Information and Data:

This step is covered with the collection of experiential facts and data. A group of experts from academia and 6 from industry) were asked to estimate the selected key dimensions critical to supply chain performance. The experts retain substantial experience in managing quality and supply chain related activities in their organization and they were Suitable to estimate the criteria and assign relative significance to these criteria in the AHP model.

Step 5: Perform Pairwise Comparisons for Each Level of Criteria:

Once the spectators are linked and applicable empirical information and data were collected, the coming step is to determine the relative significance among the criteria at each position. For this, the AHP approach was used to measure the strength of significance by pair-wise comparison and it formulates the results into a matrix form. Using a nine-point scale suggested by Saaty (1980), (Table2), the spectators were requested to assess a pair-wise comparison among the 10 factors orders.

With the use of Table 2, the pairwise comparison matrix for the ten confines is calculated (Table 3). Table 3 shows the numerical conditions recommended by the spectators for the force chain Inhuman confines. If a variable X admit a score of 'a 'in a pair-wise comparison with variable Y, the outcome for variable Y with respect to X would be 1/a. In this illustration, if an annotator decide that demand soothsaying is veritably strong or has demonstrated significance over information distortion, also predicated on scale of preference between the two rudiments, a number '9'has to be assigned. Hence, reciprocally the information deformation is 1/ 9 times lower strong than demand soothsaying. As a result, a matrix of standing was attained (Table 3). The coming step is to gain a regularized matrix, which is fulfilled by dividing each entry in column i of Table 3 by the sum of the entries in column i (Table 4).

Finally, by computing the average of the entries in row i of Table 4, priority weights were produced (Table 5). Priority means the relative importance or strength of influence of a criterion in relation to other criterion that is placed above it in the hierarchy. From Table 5, it can be observed that the priority is given to demand forecasting with the value, 0.2258, which is the most important dimension that contributes towards effective supply chain coordination, followed by company processes with a priority value of 0.2014, and then to mutual understanding factors 0.1627, and so on.

Table 2 Scale of Relative Preference for Pair-Wise Comparison

Scale	Judgments of Preferences
1	Equal importance
3	Moderate importance of one over the other
5	Essential or strong importance
7	Very strong or demonstrated importance
9	Extreme or absolute importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

Table 3 Pair-Wise Comparison Matrix

S.No.	Criteria	DF	LT	IP	NE	CP	MUF	FI	RF	QI	ID
1	LI	1	5	3	7	1	2	5	3	5	9
2	LT	1/5	1	1/3	2	1/3	1/3	3	1/5	2	3
3	IP	1/3	3	1	5	1/3	1/3	2	3	3	5
4	NE	1/7	1/2	1/5	1	1/7	1/7	1/3	1/3	1/3	3
5	CP	1	3	3	7	1	2	3	3	5	7
6	MUF	1/2	3	3	7	1/2	1	3	3	5	7
7	FI	1/5	1/3	1/2	3	1/3	1/3	1	3	3	5
8	RF	1/3	5	1/3	3	1/3	1/3	1/3	1	3	5
9	QI	1/5	1/2	1/3	3	1/5	1/5	1/3	1/3	1	3
10	ID	1/9	1/3	1/5	1/3	1/7	1/7	1/5	1/5	1/3	1
	Sum	4.02	21.66	11.90	38.33	4.31	6.81	18.20	17.06	27.66	48.0

Table 4 Normalised Matrix

S. No	Criteria	DF	L1	IF	NE	CF	MUF	Fl	RF	QI	ID
1	DF	0.2487	0.2308	0.2521	0.1826	0.2315	0.2933	0.2747	0.1758	0.1807	0.1875
2	LT	.0497	0.0462	0.0280	0.0522	0.0772	0.0489	0.1648	0.0117	0.0723	0.0625
3	IF	0.0829	0.1385	0.0840	0.1304	0.0772	0.0489	0.1099	0.1758	0.1084	0.1042
4	NE	0.0355	0.0231	0.0168	0.0261	0.0331	0.0209	0.0183	0.0195	0.0120	0.0625
5	CP	0.2487	0.1385	0.2521	0.1826	0.2315	0.2933	0.1648	0.1758	0.1807	0.1458
6	MUF	0.1244	0.1385	0.2521	0.1826	0.1158	0.1466	0.1648	0.1758	0.1807	0.1458
7	Fl	0.0497	0.0154	0.0420	0.0783	0.0772	0.0489	00549	0.1758	0.1084	0.1042
8	RF	0.0829	0.2308	0.0280	0.0783	0.0772	0.0489	0.0183	0.0586	0.1084	0.1042
9	QI	0,0497	0.0231	0.0280	0.0783	0.0463	0.0293	0.0183	0.0195	0.0361	0.0625
10	ID	0.0276	0.0154	0.0168	0.0087	0.0331	0.0209	0.0110	0.0117	0.0120	0.020
	Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 5 Priority Weights

S. No.	Dimensions	Priority Weight	Ranks
1	**Demand forecasting**	**0.2258**	**I**
2	**Lead time**	**0.0613**	**VII**
3	**Inventory policy**	**0.1060**	**IV**
4	**Number of echelons**	**0.0268**	**IX**
5	**Company processes**	**0.2014**	**II**
6	**Mutual understanding factors**	**0.1627**	**III**
7	**Flow of information**	**0.0755**	**VI**
8	**Responsiveness factors**	**0.0836**	**V**
9	**Quality improvement**	**0.0391**	**VIII**
10	**Information distortion**	**0.0178**	**X**

Step 6: Check the Consistency in the Pair-Wise Comparison:

To check the uniformity whether the created pairs of criteria are consistent or not, AHPmodel provides a measure called "Consistency ratio" (CR). It is extrapolated from the ratio of the uniformity of the result being tested to the consistency of the same problem evaluated with a random number. CR is calculated according to the following equation: CR = Cl/RI. Consistency index (CI) is obtained by the following equation: CI = $ë_{max}$-n/n-1, where 'n' is the number of criteria of each level and $ë_{max}$ is the average value of eigenvector in Table 6.

The appropriate value of random index (RI) is selected from Table 7. To obtain the eigenvector (Table 6), the following sub-steps were performed.

• Compute ä (i.e., Table 3 multiplied by Table 5)
• Compute the eigenvector 'ë'

ë = *i*th entry in ä / *i*th entry in priority weight

Table 6 Consistency Ratio (CR)

S. No.	Dimensions	ä	Eigenvector (ë)
1	Demand forecasting	2.5489	11.2896
2	Lead time	0.6916	11.2737
3	Inventory policy	1.2287	11.5896
4	Number of echelons	0.2824	10.5415
5	Company processes	2.2396	11.1209
6	Mutual understanding factors	1.8633	11.4518
7	Flow of information	0.8529	11.3001
8	Responsiveness factors	0.9342	11.1815
9	Quality improvement	0.4099	10.4785
10	Information distortion	0.1903	10.6853
	Average		110.9125/10=11.0912

Note: CI = 0.1212; RI = 1.51; CR = 0.0803 for n = 10.

Table 7 Consistency Ratio Random Number Index

Size of Matrix	1	2	3	4	5	6	7	8	9	10
Random index (RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Source: Saaty (1988)

Table 6 shows the value of ë for the ten supply chain dimensions and the average eigenvector denoted by $ë_{max}$, which is further chosen to calculate CI. If CI is sufficiently small, the evaluator's comparisons are probably consistent enough to give useful estimates of the priority weights for the goal or objective. If CR <0.10, the degree of consistency is acceptable (Dyer and Foreman, 1992), but if CR is> 0.10, serious inconsistency may exist, and AHP may not yield meaningful results. Then, the assessment can be revised. In our case, the CR is 0.0803; thus, the degree of consistency of pair-wise comparison of supply chain dimensions is considered to be satisfactory (CR < 0.10).

Step 8: Incorporate Findings and Improve Dimensions:

From the calculation carried out in the previous step, one can priorities and rank the factor categories for improving SCM performance and can deal the resources accordingly to achieve maximum benefits. The use of AHP has generic applications because its structure and hierarchy can be easily modified to incorporate specific features (Banuelas& Antony, 2003). AHP can, therefore, be adopted for prioritizing various dimensions

Results and Analysis

Table 5, shows the priority weights of various practices that are normalized based on AHPanalysis. It is observed that the priority is given to demand forecasting with the value, 0.2258, which is the most important dimension that contributes towards effective supply chain coordination, followed by company processes with a priority value of 0.2014, and then to mutual understanding factors 0.1627, inventory policy 0.1060 and so on. It can be observed from the results of this study that, Demand forecasting, company process and mutual understanding factors were the most critical factors that affecting the SCM performance in the manufacturing industries.

In this paper, an extensive literature review was carried out to identify various dimensions that help in improving performance of SCM in manufacturing industry. Ten such dimensions were identified. The study further identifies the priority ranking of these dimensions for the manufacturing industries. Understanding their relative importance, manufacturing industries can evaluate their prevailing practices and distribute reasonable resources and efforts to these dimensions to improve their SCM performance. Therefore, in order to strengthen the competitive advantage of organizations, management teams of organizations should change their employees' attitudes towards learning.

Limitations

This study was conducted in one country only. Future exploration may include other countries to make the study more applicable and generalizable. The outcome of this study is limited in their scope because of one of the reasons that the study is based on the judgments of only ten experts 4 from academia and 6 from industry from one country only.

Conclusions and Future Scope

These days most of the decisions are to be taken in increasingly multifaceted situations because competition is between integrated supply chains rather than individual organizations', which is a transparent technique, is very useful to handle this type of situations were qualitative data is involved in the decision-making. In this study, ten dimensions were identified from the literature review and discussion with the experts in the area for improvingSCM performance. The AHP approach has been used to perform pair-wise comparison and priorities the dimensions. In this research, it was found that demand forecasting is considered of greater importance for SCM.

This study is based on exploratory in nature, provides insight into determining the effectiveness of various dimensions. The study is done considering the various dimensions alone. Future research could be validating the criteria proposed in this research. Further, a self-assessment system must be developed so that industry can evaluate its current performance. This will help to identify strength and weaknesses, and will provide information to develop appropriate strategies for making improvements. In this research, empirical study is conducted to develop and analyses the model, however optimization techniques can also be used to further analyze and validate the model.

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