Evaluation of Supply Chains of the Organizations through Dematel/AHP

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Abstract:
In recent years, performance measurement and metrics of organizations have received much attention from researchers and practitioners. The role of these measures and metrics in the success of an organization cannot be overstated because they affect strategic, tactical and operational planning and control. Performance measurement and metrics have an important role to play in setting objectives, evaluating performance and determining future courses of actions. Performance measurement and metrics pertaining to leagile supply chains have not received adequate attention from researchers or practitioners. In the area of supply chain management, application of MCDM methods is limited to supplier selection and transportation carrier selection.
In this paper, fifteen organizations involved in production of apparels in Telangana and Andhra Pradesh are considered for evaluation of supply chain strategies in leagile perspective using DEMATEL-AHP methodology. AHP frame work is developed with level 0 as goal of analyzing the leagile performance of the supply chains. Performance measures are considered in level 1. Level 2 contains enablers of the performance measures of leagile supply chains. Level 3 contains fifteen supply chain organizations. Weights of the performance enablers are determined through FPIR and FNIR approach without interdependence. DEMATEL is employed to determine the relative weights of the performance enablers from interdependence. DEMATEL is employed to determine the relative weights of the performance enablers from interdependence. Global weights of performance enablers are determined by successively multiplying the weights of performance measures with the weights respective enablers. Evaluation of supply chains in leagile perspective is done by finding out leagile index obtained by weighted sum of payoff of the enablers.

Keywords: Leagile supply chain strategy, Leagile index, Performance measurement, Performance enablers, Flexibility

1. Introduction

Performance measurement and metrics pertaining to leagile supply chains have not received adequate attention from researchers or practitioners. To know the performance of the supply chains of them organizations implementing leagile strategy requires an evaluation methodology. Evaluation of leagile supply chains is helpful to the decision-maker to improve the legality of its supply chain. Evaluation of a leagile supply chains depends on multiple criteria like total supply chain cost, return on investment, flexibility, service levels, organizational performance, operational performance, customer service performance etc. In lieu of this, evaluation of leagile supply chain chains is considered as Multi-Criteria Decision-Making (MCDM) problem. Several authors solved MCDM problems without considering vagueness in the decision-maker's subjective judgments.
In this paper, evaluation of the supply chains of organizations in leagile perspective is carried out using AHP and DEMATEL as hybrid method in fuzzy environment. The hybrid model is illustrated with a case study.

1.1. Performance Assessment of Leagile Supply Chains

Vickery et al. (1991), considered that the organizational performance refers to how well an organization achieves its market-oriented goals as well as its financial goals in terms of performance items such as return on assets, market share and growth rate.
Christopher and Towill (2001), presented the actions required to qualify in the market and to win orders in the supply chain. The authors identified quality, cost, response time and service level as the performance indicators of the supply chain performance.

Bhatnagar and Sohal (2005), identified proposed supply chain performance measurement indicators namely; lead time, inventory, time to market, quality, delivery and flexibility on plant location factor, supply chain uncertainty and manufacturing practices to determine supply chain competitive advantages.

Agarwal et al. (2006), proposed a framework which encapsulates the market sensitiveness, process integration information driver and flexibility measures of supply chain performance. The proposed framework analyzed the effect of market winning criteria and market qualifying criteria on the three types of supply chains: lean, agile and leagile.

Vildan and Tufan (2011), explored the strategies for design and performance measurement of different supply chain types. In the study, supply chain performance is analyzed basing on the indicators under market sensitiveness, reliability, accessibility and flexibility.

El-Baz (2011) presented performance measurement approach based on fuzzy set theory and Analytical Hierarchy Process (AHP) in supply chain systems.

Kazemhkanlou and Ahadi (2014), made a literature survey on performance dimensions and its measures of supply chain. In the study, it was identified that there is a shift from the traditional performance measures like ROI, ROA, etc., to non-traditional performance measures like quality, flexibility, etc.

Evaluation of leagile supply chains are considered as multi-criteria decision making problem and DEMATEL/AHP method was used as a hybrid model to rank the leagile supply chains. DEMATEL is implemented in fuzzy environment to know the interdependence between the performance measures as well as the sub-criteria under each performance measure. AHP is adopted to aggregate all local priorities by a simple weighted sum. The global priorities thus obtained are used for final ranking of the supply chains. Hierarchical decomposition of decision elements of the proposed model is shown in figure1. Level '0' represents the goal i.e., Evaluation of leagile supply chain of organizations. Level '1' represents the performance measures of leagile supply chains. Performance enablers are grouped and placed under each performance measure at subsequent level. Final level contains organizations.

1.2. Dematel-AHP Methodology

The DEMATEL-AHP methodology for evaluation of leagile supply chains is illustrated with a case study. The following steps explain the proposed methodology.

> STEP1: Calculate the weights of supply chain performance enablers.

Weights of the performance enablers under respective performance measures are determined through FPIR and FNIR approach.

> STEP 2: Determining Interdependence among performance enablers using DEMATEL.
> STEP 3: Determine the weights of the performance enablers.

Weights of the performance enablers are obtained by multiplying the interdependence matrix obtained in step 2 with weights obtained in step1

> STEP 4: Find Global weights

Global weights of the performance enablers are calculated by successively multiplying the weights of performance measures with weights of respective performance enablers.
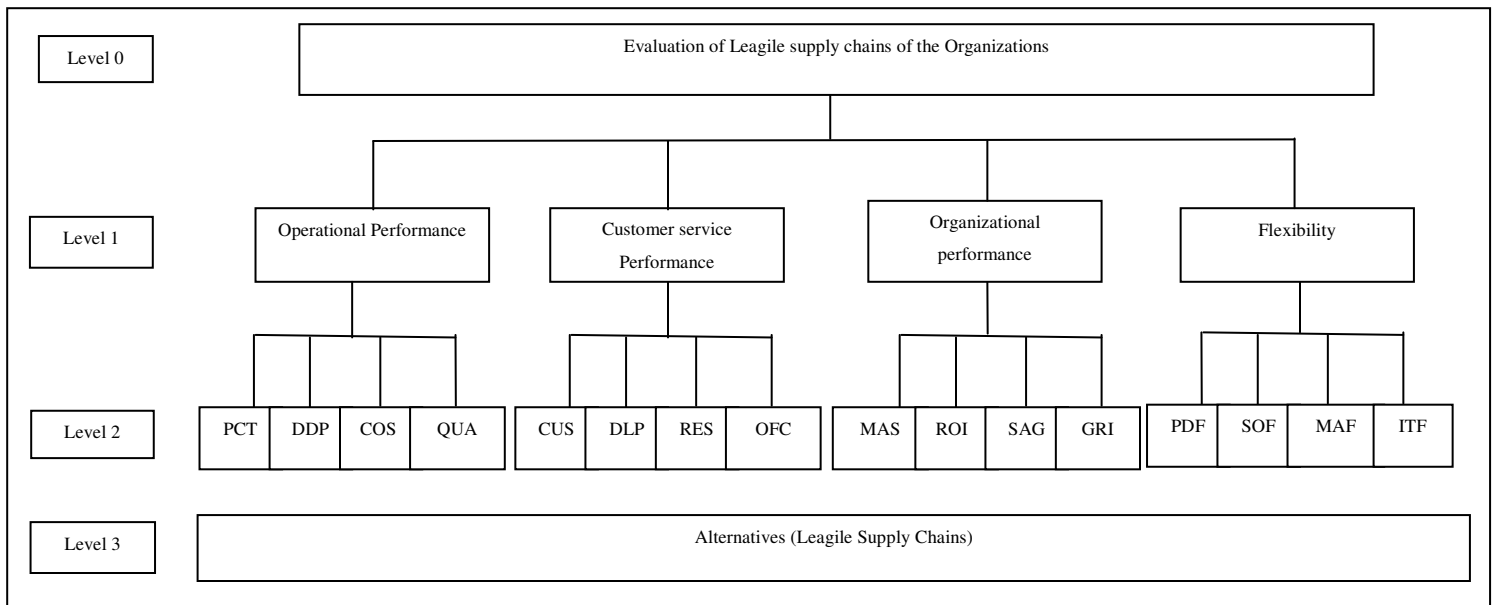

Figure 1

> STEP 5: Evaluation of leagile supply chains

Evaluation of supply chains in leagile perspective is done by finding out R_j (Leagile Index) from the following equation.

$$R_j = \sum P_{ij} w_i$$

Here P_{ij} is the payoff of the ith performance enabler of jth organization's supply chain. The weight of the ith performance enabler is denoted by w_i. Leagile index of the supply chain of jth organization (R_j) provides the basis for evaluation of the supply chain of the organization. Higher the value of R_j, the better is the supply chain in leagile perspective.

2. Case Study
In this study, evaluation of leagile supply chains of fifteen organizations as discussed in case study of chapter three through DEMATEL-AHP methodology. AHP frame work is developed with level 0 as goal of analyzing the leagile performance of the supply chains. Performance measures are considered in level1. Level 2 contains enablers of the performance measures of leagile supply chains. Level 3 contains fifteen supply chains of the organizations. Weights of the performance enablers are determined through FPIR and FNIR approach without interdependence. DEMATEL is employed to determine the relative weights of the performance enablers from interdependence.

2.1. Weights of Supply Chain Performance Enablers without Interdependence

Performance Measures	Performance Enablers	Weight
Operational Performance	Product cycle time	0.4103
	Due date performance	0.1089
	Cost	0.1526
	Quality	0.3282
Customer Service Performance	Customer satisfaction	0.3256
	Delivery dependability	0.1291
	Responsiveness	0.4137
	Orders fill capacity	0.1316
Organizational Performance	Market share	0.4734
	Return on investment	0.2677
	Sales growth	0.1125
	Green image	0.1463
Flexibility	Product development flexibility	0.4684
	Sourcing flexibility	0.3186
	Manufacturing flexibility	0.1047
	IT flexibility	0.1083

Table 1: Weights of the performance enablers

2.2. Interdependence of Performance Enablers
DEMATEL method discussed in step 2 is implemented to determine the interdependence of performance enablers using fuzzy direct influence matrix.

Performance Measures	Performance Enablers	Weight
Operational Performance	Product cycle time	0.1879
	Due date performance	0.2812
	Cost	0.2235
	Quality	0.3073
Customer Service Performance	Customer satisfaction	0.2236
	Delivery dependability	0.2187
	Responsiveness	0.3007
	Orders fill capacity	0.2571
Organizational Performance	Market share	0.2424
	Return on investment	0.2169
	Sales growth	0.2696
	Green image	0.2710
Flexibility	Product development flexibility	0.1523
	Sourcing flexibility	0.2194
	Manufacturing flexibility	0.2837
	IT flexibility	0.3446

Table 2: Weights of the performance enablers from interdependence

From table 1, it is observed that highest relative weight (0.3446) is obtained with IT flexibility followed by quality (0.3073) and responsiveness (0.3007). Moderate weights are obtained with MAF (0.2837), DDP (0.2812), GRI (0.2710), SAG (0.2696) and OFC (0.2571). Other performance variables show relatively less weights.

2.3. Global Weights
Global weights of performance enablers are determined by successively multiplying the weights of performance measures with weights of respective enablers. The global weights are shown in the following table.
Enablers of the framework are those which assist in achieving the controlling performance measure of supply chain performance. Table 2 indicates the global weights of the enablers calculated basing on the hierarchy. These global weights are useful in evaluating supply chains of the organization in leagile perspective. Weights of the performance measures and global weights of their enablers are shown in figure 1.

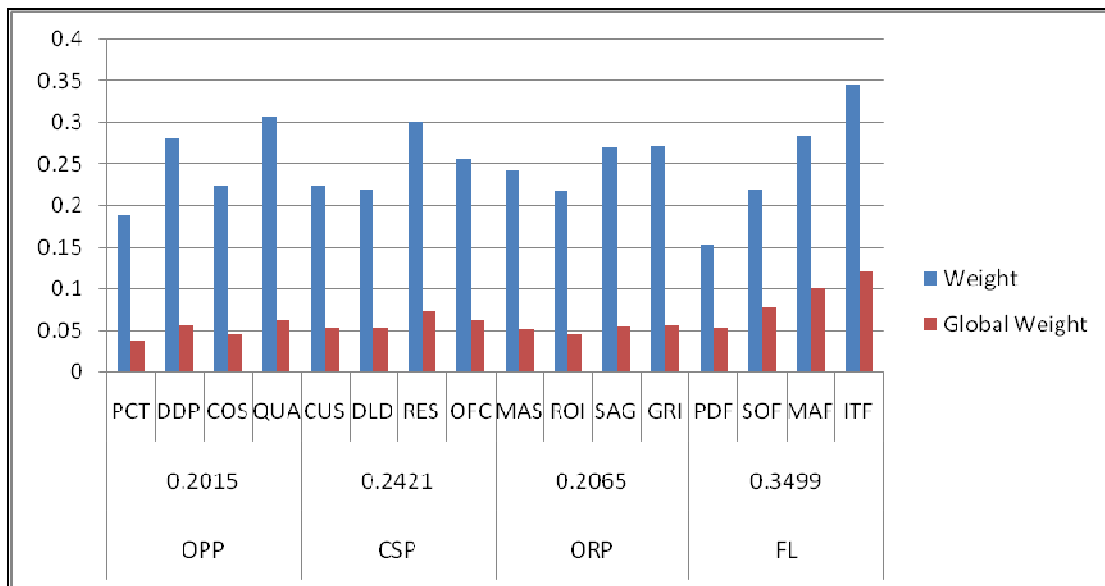| Performance Measures	weight	Performance enablers	Weight	Global Weight
OPP	0.2015	PCT	0.1879	0.0379
		DDP	0.2812	0.0567
		COS	0.2235	0.0450
		QUA	0.3073	0.0619
CSP	0.2421	CUS	0.2236	0.0541
		DLD	0.2187	0.0529
		RES	0.3007	0.0728
		OFC	0.2571	0.0622
ORP	0.2065	MAS	0.2424	0.0501
		ROI	0.2169	0.0448
		SAG	0.2696	0.0557
		GRI	0.2710	0.0560
FL	0.3499	PDF	0.1523	0.0533
		SOF	0.2194	0.0768
		MAF	0.2837	0.0993
		ITF	0.3446	0.1206

Table 2: Global weights of performance enablers

Figure 2: Global Weights of Performance enablers

From fig 2, it is understood that ITF is the most import performance enabler having highest weight (0.1206) followed by MAF, SOF, RES and OFC. Other sub-criteria show less important.

2.4. Evaluation of Supply Chains of the Organizations in Leagile Perspective
Data on the performance enablers of fifteen organizations is collected in terms of fuzzy linguistic variables through a questionnaire shown in Appendix is supplied to the personnel involving purchasing, production, marketing & sales and customers of the industries to know the present status on the performance enablers. The linguistic variables of the performance enablers of the fifteen organizations are aggregated. These linguistic variables are assigned with trapezoidal fuzzy numbers and this fuzzy data is converted into crisp data using the methodology proposed by Gharakhani (2012). Evaluation of the supply chains of the organizations is carried out using pay off of the enablers of the organizations and relative weights of the enablers.

3. Results and Discussion
Supply chains of the organizations discussed in the case study are evaluated basing on the Leagility index as discussed in step 5 of the methodology (section 6.2). Evaluation of the organization in leagile supply chain perspective is shown in table 3.

Supply chains	Leagile Index	Supply chains	Leagile Index	Supply chains	Leagile Index
O1	0.5594	O6	0.4378	O11	0.5336
O2	0.5171	O7	0.3884	O12	0.4314
O3	0.5468	O8	0.3941	O13	0.3558
O4	0.5042	O9	0.4298	O14	0.5512
O5	0.3046	O10	0.4380	O15	0.3856

Table 3: Evaluation of Lean and Agile Supply Chains
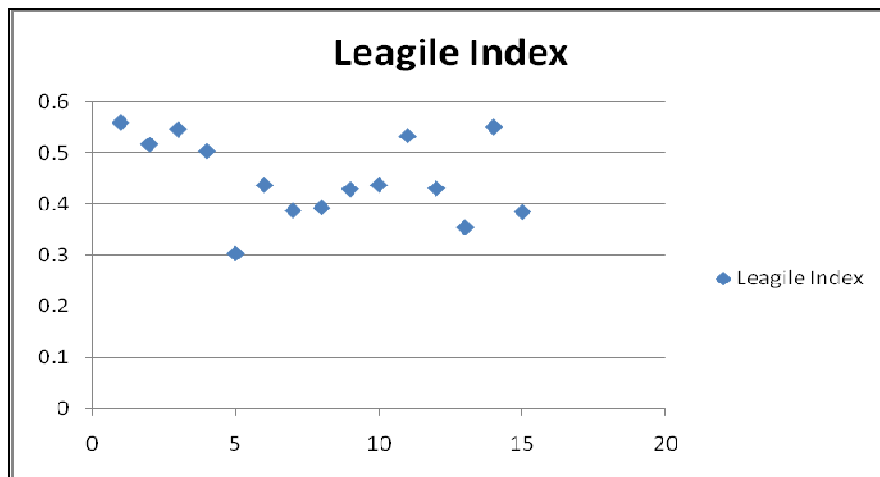

Figure 2: Leagile indices of the organizations.

From the figure it is observed that the organizations: O1 (0.5594), O14 (0.5512), O3 (0.5468), O11 (0.5336), O2 (0.5171) and O4 (0.5042) show the best performance in leagile perspective as the leagile indices of these organizations are more than 0.5. The organizations namely: O10 (0.4380), O6 (0.4378), O12 (0.4314) and O9 (0.4298) show moderate performance in leagile perspective as the leagile indices of these organizations are between 0.4 and 0.5. Remaining organizations show less performance in leagile perspective as the leagile indices of these organizations are less than 0.4.
In the study, highest global weight is obtained with ITF followed by MAF, SOF and RES. The organizations namely, O1, O3 and O14 show highest payoff in ITF. In case of MAF, O3 and O7 show highest payoff. The organizations namely: O2 and O3 show highest payoff in respect of SOF. RES is having the highest payoff in respect of organizations namely: O2, O7 and O14. Hence, leagile performance of the supply chains of the organizations depends not only on the global weights of the performance enablers but also on the payoff of the performance enablers.

4. Concluding Remarks
AHP frame work is developed with level 0 as goal of analyzing the leagile performance of the supply chains. Performance measures are considered in level1. Level 2 contains enablers of the performance measures of leagile supply chains. Level 3 contains fifteen organizations. DEMATEL-AHP methodology is proposed and illustrated. The proposed methodology is a robust multi-attribute decision-making technique for synthesizing the leagile supply chains performance measures and their performance enablers in fuzzy environment. Weights of performance measures are determined through FPIR and FNIR approach. DEMATEL method is adopted to determine the weighs of the performance enablers on the basis of interdependence. Global weights of performance enablers are also obtained. Evaluation of supply chains could play a significant role in helping firms to address the present and future challenges of managing supply chains.

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